LIVING MARINE RESOURCES

The Living Marine Resources Technical Report is an overview of (1) fishery resources, including major fishery dependent monitoring programs (commercial and recreational fish landings), fishery independent monitoring and population trends of fishery species (finfish and lobster), and commercial and recreational shellfish landings, (2) population status of marine mammals and sea turtles, (3) seabird, shorebird, waterfowl and colonial waterbird populations, (4) large scale benthic community monitoring programs, and (5) status of marine bioinvaders.

1. FISHERY RESOURCES

In this section, the major data collection and monitoring programs that characterize the fishery resources, including finfish, lobster, and shellfish of Massachusetts marine and estuarine waters are described. By definition, the data programs that collect commercial and recreational fishery landings information characterize only species that are of either commercial or recreational significance. The fishery independent monitoring programs that are in place and implemented by the Massachusetts Division of Marine Fisheries (*MarineFisheries*) characterize the populations of organisms that are susceptible to the limited array of sampling devices (e.g., otter trawls and lobster traps). There are many Living Marine Resources, including a wide variety of organisms (e.g., benthic invertebrates, phyto- and zooplankton, small cryptic fishes, pelagic fishes) and environments, such as shallow water embayments and estuaries, that are not well characterized by the present programs. Characterization of populations with limited data is not included. Examples of the population status for exploited species through time are provided only for select species and geographic areas. Specifically, this summary relies on data collected only in state waters by *MarineFisheries* (i.e., does not include a summary of federal fishery programs, such as NOAA's National Marine Fisheries Service - NOAA Fisheries).

Characterization of a particular fish or invertebrate species deemed significant or important generally takes place in the context of direct or indirect economic value, although some species such as herring are also recognized for their value as forage (food) for other species. Several factors contribute to the characterizations of economically valuable species:

- *Historical use of the species* – Species such as striped bass and lobster have been harvested off the Massachusetts coast for at least 400 years, and cod even longer.
- *Value of landings* – American lobster, for example, is Massachusetts most valuable single species fishery (landings are typically worth $50-60 million dollars annually).
- *Indirect value to local economies* – Money spent on lodging, meals, boat charters, and the like in the pursuit of species such as striped bass, bluefish, or tuna that support a significant portion of the local economy of many coastal towns.
- *Compliance with Federal or Regional Regulatory Processes* – As well as the species mentioned above, numerous other species such as scup, black sea bass, winter flounder, squid, conchs, and summer flounder, are regulated under multi-state management plans that require the collection of landings data.

Further data on landings and population status are available through NOAA Fisheries (e.g., Status of Fishery Resources; Clark 1998). The NOAA documents present changes in traditionally exploited species (e.g., groundfish and flounders) and species that have recently gained economic value (e.g., skates and dogfish).

A. Commercial Fish Landings

MarineFisheries and NOAA's Fisheries manage a long-term database on the landings of commercially valuable species. These data sets provide the foundation to monitor and examine trends in species landed throughout the Commonwealth.

The Atlantic Coastal Cooperative Statistics Program (ACCSP; see www.accsp.org for more information about the program) has existed for several years. The goal of ACCSP is to collect and manage compliant or trip-based, commercial landings, and catch and effort data, in Massachusetts, with all partners (all Atlantic States and Federal Agencies) Massachusetts is unique in that two organizations, *MarineFisheries* (DMF) and NOAA Fisheries (NMFS) both have established commercial fisheries landings and catch and effort data collection mechanisms in place.

CURRENT STATUS OF LANDINGS DATA

1. ***MarineFisheries* (MA Division of Marine Fisheries)**: *MarineFisheries* has been collecting commercial landings and catch and effort data in one form or another for over thirty years. The emphasis of this data collection effort has been directed at the lobster fishery, as it is the most economically important fishery conducted within the state's territorial waters. Other fisheries include striped bass, fluke, fish weir, gillnet, fish-pot (sea bass, scup, and conch) and shellfish. This information is collected via annual catch reports, submitted at license renewal time, which detail catch and effort data by month, not by trip. In addition, DMF *MarineFisheries* collects dealer landings data on a weekly basis from dealers who have authorization to purchase quota monitored species. These weekly purchases are corroborated by year-end transaction sheets, or federal dealer weigh-out slips, which detail each transaction with fishermen. Finally, DMF *MarineFisheries* issues permits to all commercial fishermen and seafood dealers in Massachusetts. This is important as *MarineFisheries* can identify all fishermen and dealers in the state, regardless of whether they have a federal permit or not.

   While *MarineFisheries* collects these important landings data, there are several known problems in the current monitoring programs. For example, data is not trip-based, data reporting is not timely, data accuracy can be lost because fisherman are completing the landings report only once each year, potentially months after fishing occurred, and not all catch and effort data recorded.

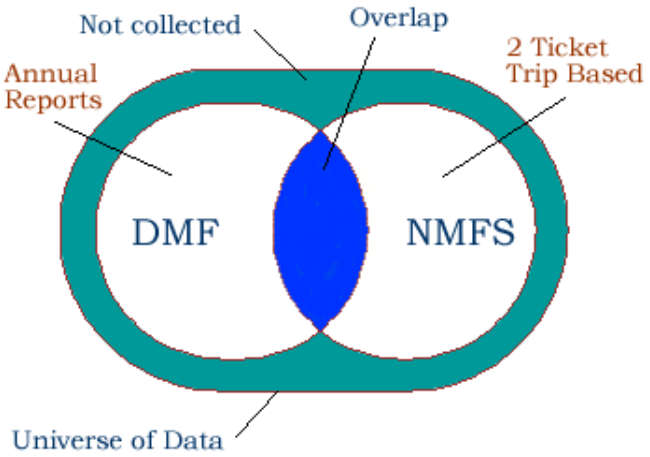
2. **NOAA Fisheries (NOAA's National Marine Fishery Service):** NOAA Fisheries also collects commercial landings and catch and effort data in Massachusetts for a number of years. The emphasis of its data collection efforts center more on vessels which fish in federal waters and seafood dealers that purchase from these federally permitted vessels. All species and gear types are surveyed, but for federal permit holders only. Data are collected in a trip-based format, featuring a two-ticket system. The vessel completes a vessel trip report (VTR) for each trip and the dealer completes a dealer weigh-out when purchasing from a vessel. NOAA Fisheries also maintains

landings information for quota monitored species, although in Massachusetts these data are actually collected by *MarineFisheries* and then passed along to NOAA Fisheries on a weekly basis. Finally, NOAA Fisheries permits only those vessels fishing in federal waters and those dealers that purchase from federally permitted vessels.

Limitations to NOAA Fisheries data collection methods include the fact that 1) only federally permitted vessels and 2) dealers submit reports and unmatched records occur in a two-ticket system (dealers sometimes can't identify vessels and vessels sometimes can't identify dealers).

Other Issues Related to Monitoring Commercial Fish Landings: When considering an ACCSP compliant trip-based solution for Massachusetts, there are three other major issues that must be addressed when looking at the current situation:

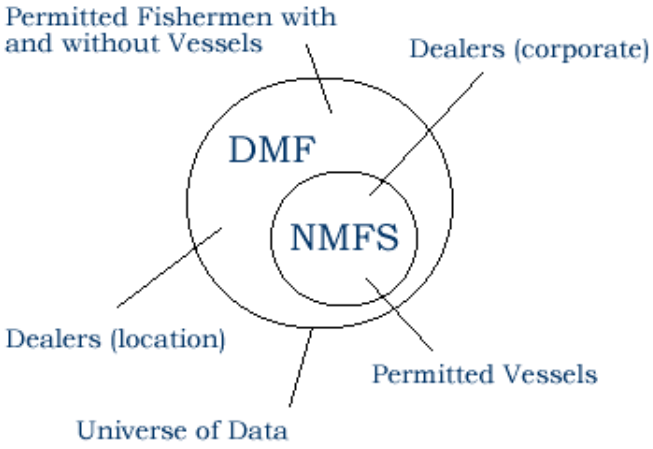
- *Two independent agencies*. Two independent agencies with existing programs (staff, infrastructure and business processes), data time-lines, difference in data elements, and most importantly, the trust each agency has in one another, exist. If these two agencies are to come together to collect ACCSP compliant data, some major changes will be required by one or, most likely both, to accomplish this.
- *Two agencies collecting both independent and overlapping data*. Not only are the mechanisms different (annual report vs. trip-based; species or gear based report vs. all species and gears report), but also some data collected by each agency *are not* collected by the other, and some data collected by each agency *are* collected by the other. In addition, some data *are not collected at all* by either agency.



MA Commercial Catch & Effort Data

- *Two agencies have permitting systems, again which have both independent and overlapping permit holders*. DMF *MarineFisheries* issues permits to all commercial fishermen, not vessels, whether they fish in federal waters or not. DMF *MarineFisheries* also issues permits to all seafood dealer locations in Massachusetts. NOAA Fisheries on the other hand, issues permits only to vessels that fish in federal waters (which includes vessels that fish in both federal and territorial waters); they do not issue permits to vessels that only fish in state

waters. In addition, NOAA Fisheries permits seafood dealers that buy from these federally permitted fishermen. The NOAA Fisheries dealer permit is not associated to the location, but rather the corporation. In other words, a dealer may have several locations in Massachusetts, but NOAA Fisheries only issues one permit to that corporation.



MA Commercial Permits

CURRENT SOLUTION TO MANAGEMENT OF LANDINGS DATA

Given the disparate systems to monitor landings data, how can two agencies continue to collect commercial landings, catch and effort data in Massachusetts while meeting ACCSP guidelines? Furthermore, how can a solution eliminate duplication and impose the least amount of burden on the seafood industry while providing timely, accurate data?

As of November 2003, *MarineFisheries*, NOAA Fisheries, and ACCSP are working towards implementing the following plan, which addresses a change in how landings data are collected. A federal mandate has been issued which requires that all federally permitted dealers report their primary purchases from fisherman starting May 1, 2004. As a result, DMF *MarineFisheries* will host an electronic dealer reporting application (based on ACCSP guidelines), which will allow all dealers in Massachusetts, who are primary buyers of seafood product, to log their purchases from fishermen on line. NOAA Fisheries and ACCSP will receive regular downloads of the data. While the new electronic dealer reporting system will be in place on May 1, 2004, not all primary buyers in Massachusetts will participate immediately for various reasons (no computer, no internet access, using existing accounting software to record landings already, etc.). Indeed, it is likely to take one to two years to bring all dealers on board. A federal grant application has been submitted (approval pending) to fund two new positions within *MarineFisheries* and an Oracle contract to get this project started. However, long-term funds are needed to maintain the project.

Unfortunately, this solution only addresses landings data in Massachusetts; it does not provide a solution for solving the disparity and gaps revolving around catch and effort data from fishermen. The lack of gear and area specific data on data for landings catch and effort that is gear and area specific continues to cause difficulties with assessment and management decisions. Considerable funding and coordination will be required to craft a solution to this problem. Presently, NOAA Fisheries will continue to collect vessel trip reports from federally permitted fishermen, and *MarineFisheries* will continue

to collect annual catch reports from select commercial fishermen. Considerable funding and coordination will be required to craft a final solution.

In conclusion, it is clear that the building blocks for ACCSP compliant data collection methodologies are in place. Many years were spent by all Atlantic states and federal agencies planning and building an information system that would store standardized marine fisheries data for the entire Atlantic Coast. The organization (i.e., format of the data and the repository) is in place. The current goal is to have all partners begin contributing data. Currently, some states are doing so, but Massachusetts is not.

The depiction and discussion of long-term trends for these and other species is beyond the scope of this document. Some important species (e.g., cod) are not presented because detailed area data are not collected in state waters via through the current programs. However, the following graphics present the geographic distribution and magnitude of landings by gear type or species in 2002 for Massachusetts (Figures 1-3). These data have been provided to illustrate the type of information collected via the procedures described above. The species and gear types selected are those that are particularly important to the Massachusetts state waters fisheries and for which detailed catch records are available.

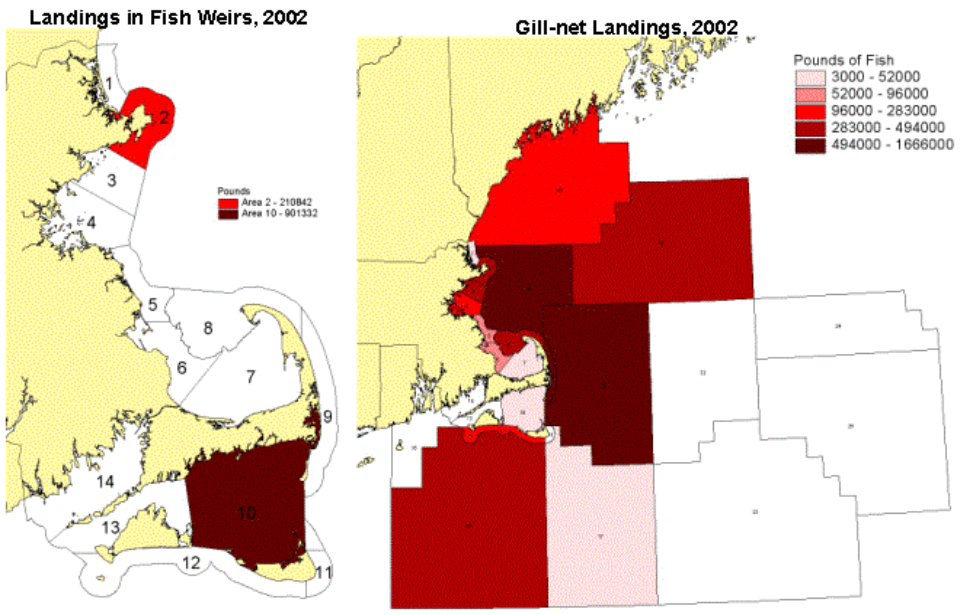


Figure 1. Commercial fish landings from fish weir in state waters and gill-net fisheries from state and federal waters in 2002. Fish weir data shown for Massachusetts waters; gill-net landings shown for state and federal waters.

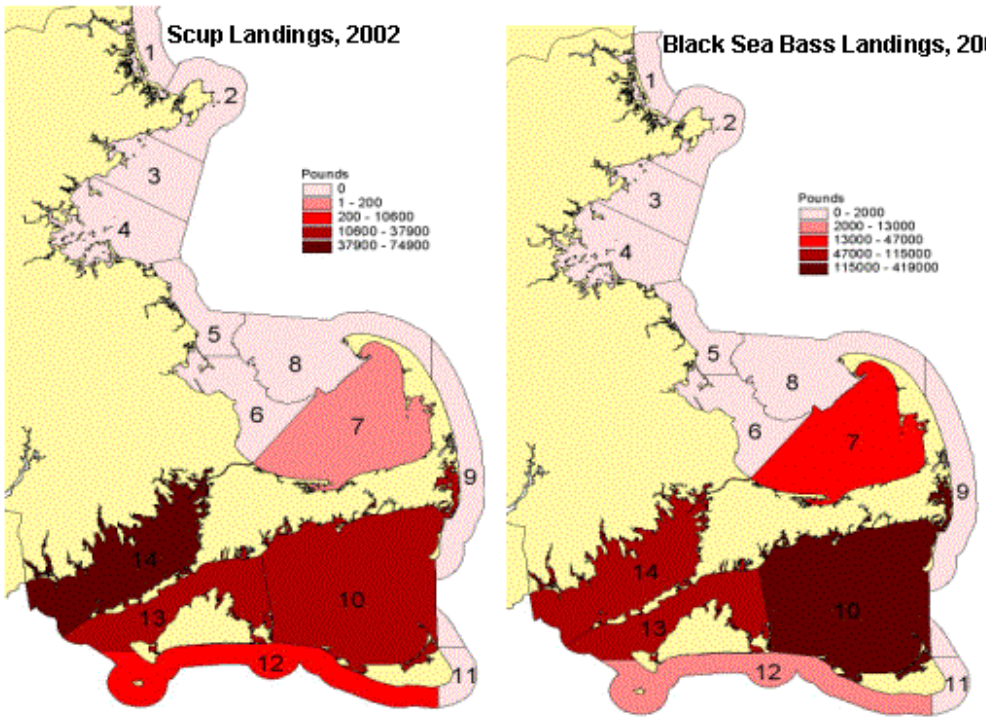


Figure 2. Commercial landings of scup and black sea bass in Massachusetts for 2002.

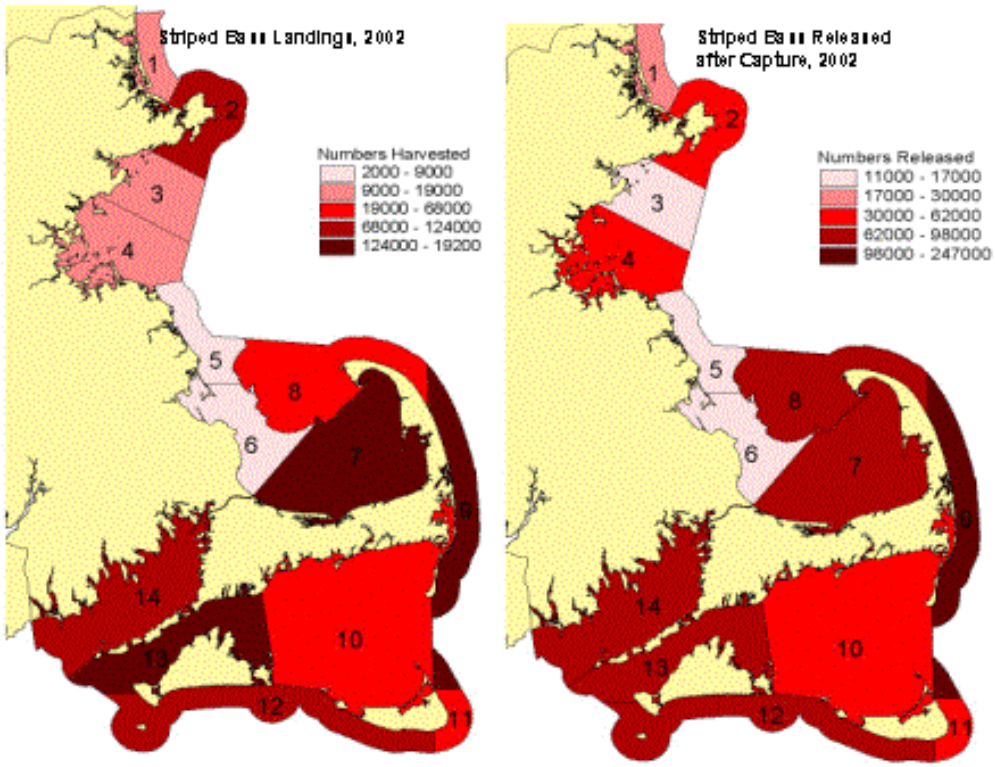


Figure 3. Striped bass landings and release after capture in Massachusetts for 2002.

B. Recreational Fish Landings: Marine Recreational Fisheries Statistical Survey

The Marine Recreational Fisheries Statistical Survey (MRFSS) is a NOAA Fisheries project, jointly funded by the federal and state governments and ACCSP, that provides

state-specific estimates of catch and harvest by recreational anglers, number of angler over time, and number of boats over time along the East Coast. Based on field surveys and telephone interviews, these estimates form the basis for many management decisions and are used extensively in stock assessments. In general, the estimated catches positively track the abundance of species. For example, the graph of recreational catches of summer flounder and striped bass reflect the increasing population size for both species (Figure 4).

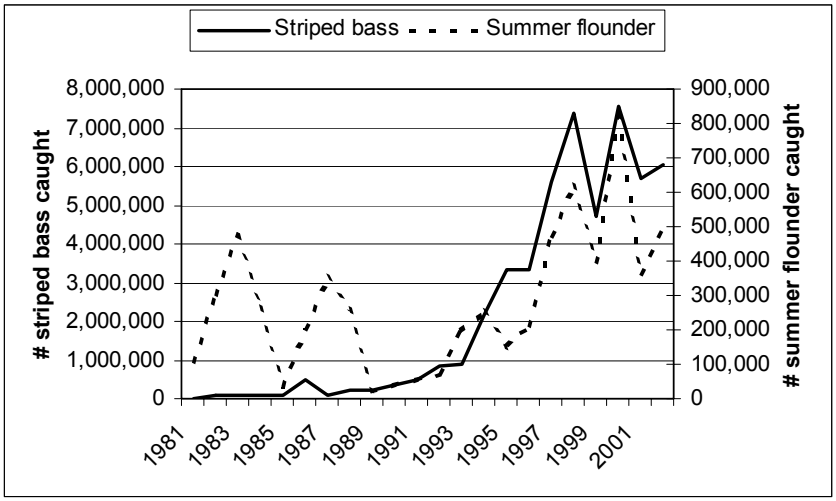


Figure 4. MRFSS estimates of the number of striped bass and summer flounder caught by recreational anglers, 1981-2002.

C. Population Trends for Fishery Species – Fishes and Lobster

The following section describes programs that are in place to monitor population trends in marine and estuarine species. Data presented for selected fishery species is an example of the type of data collected in specified areas (e.g., spring biomass). However, these examples are not a complete assessment of the status of these stocks throughout Massachusetts or throughout the species geographic range. NOAA Fisheries (NMFS) also conducts an extensive stock assessment that incorporates *MarineFisheries* data. The NOAA Fisheries program provides the definitive assessment of US fishery stocks, but these data are not presented in this summary.

The *MarineFisheries* programs target certain species or a suite of species that generally have high economic value and therefore, many species are not represented in these collections. This is a review major of *MarineFisheries* ongoing and previous monitoring projects, including: (1) The Resource Assessment Project – Inshore Bottom Trawl Survey, (2) Winter Flounder Young-of-the-Year Seine Survey, (3) Coastal Lobster Investigations, (4) Nearshore Embayment Studies, (5) Large Pelagic Fishes, and (6) Shellfisheries.

These programs sample a wide variety of vertebrate and invertebrate species but the suite of species sampled are limited to those that are susceptible to the survey gear and area sampled. Thus, there is a paucity of data and trends for many species that inhabit Massachusetts waters.

1) Select Fishes and Invertebrates

MA DMFMARINE FISHERIES RESOURCE ASSESSMENT PROJECT – INSHORE BOTTOM TRAWL SURVEY

MarineFisheries' Resource Assessment Project (RAP) has conducted bottom trawl surveys of Massachusetts territorial waters in May and September since 1978. This represents the longest state operated trawl survey time-series in the region.

Survey Design

The MA DMF Survey coverage extends from the New Hampshire to Rhode Island borders seaward to three nautical miles including territorial waters of Cape Cod Bay and Nantucket Sound; both areas of special jurisdiction to Massachusetts fisheries management. The Inshore Bottom Trawl Survey objectives are: (1) to determine the distribution and relative abundance of recreationally and commercially important fish species in state waters; (2) to collect biological samples; and (3) to collect physical data including geographic location, depth, and hydrographic information. The waters delineated above are stratified into geographic zones (strata) based on depth and area (Figure 5). Trawl sites are allocated in proportion to stratum area and chosen randomly within each sampling stratum. Sites are occasionally relocated due to concentrations of fixed gear or because of untowable bottom.

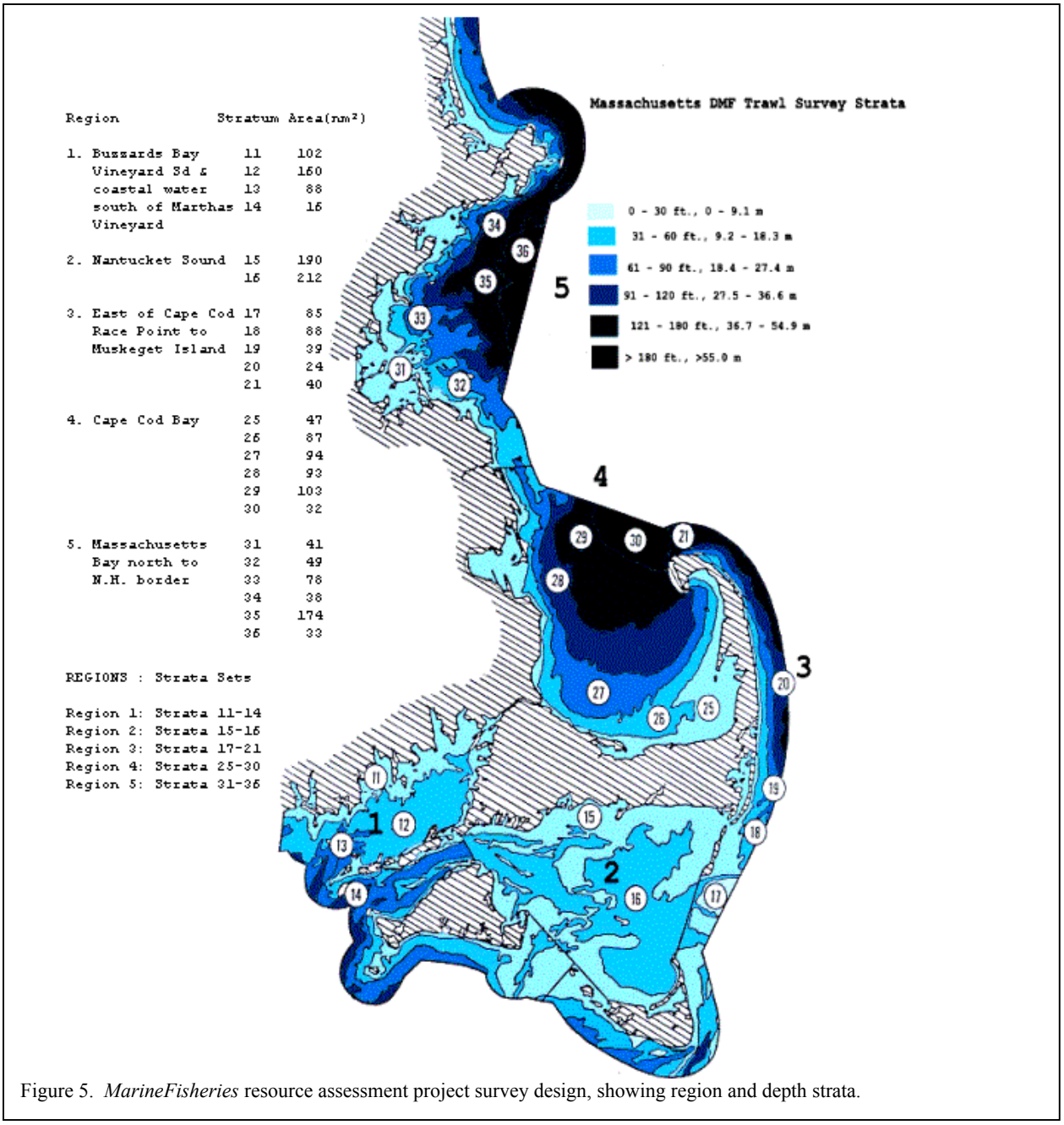


Figure 5. *MarineFisheries* resource assessment project survey design, showing region and depth strata.

A 20-minute tow at 2.5 knots is undertaken at each station with a ¾-size North Atlantic type, two seam otter trawl (11.9 m head rope - 15.5 m footrope). The net is rigged with a 15.5 m chain sweep with 8.9 cm rubber discs; 19.2 m bottom legs of 9.5 mm chain; 18.3 m wire top legs; and, 1.8 x 1.0 m, 147 kg wooden trawl doors. The net contains a 6.4 mm mesh cod end liner to retain small fish.

Standard bottom trawl survey techniques are used when processing the catch. Generally, the total weight (nearest 0.1 kg) and length-frequency (nearest cm) are recorded for each species on standard trawl logs. Age and growth material (hard parts) as well as maturity and pathology observations are collected during the measuring operation. At each station, surface and bottom temperatures and surface salinity are recorded. All of these parameters provide valuable data to examine changes to species abundance and life history characteristics through space and time.

Time Series Trends for Selected Species / Stocks

Figures 6-14 presented illustrate stratified mean weight per tow (kg) ± 2 standard errors, 1978 – 2002 for several species whose population is believed to be well represented by the trawl survey. The time period and area(s) represented differ for each graph but represent the time and area of sampling that best tracks the individual population. The median gives a general sense of the population level relative to present and historic (1978) values, but should not be used as a reference for current management targets. Error bars are relatively large in most cases due to the inherent variability of trawl sampling and the abundance and distribution of fish species.

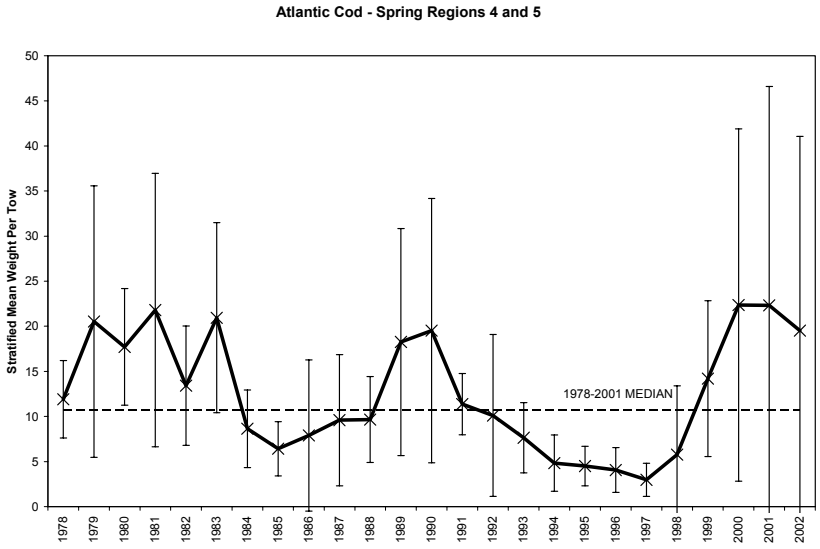


Figure 6. Atlantic cod spring abundance.

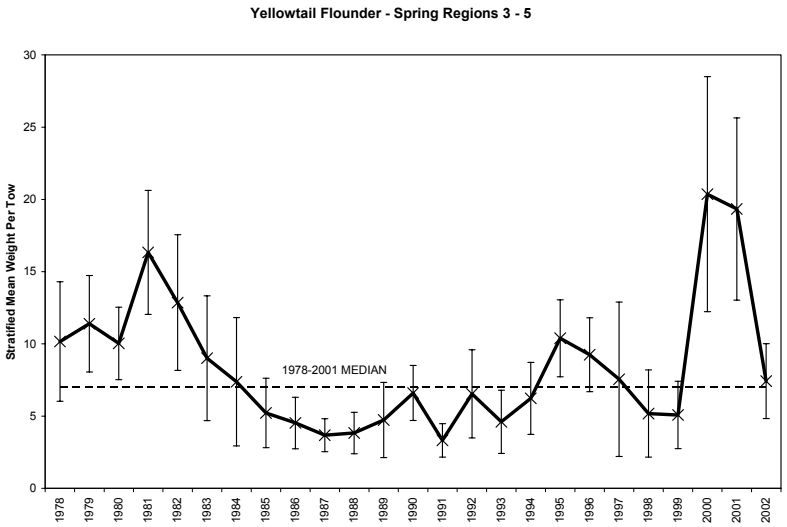


Figure 7. Yellowtail flounder spring abundance.

The MA *MarineFisheries* biomass index of **Atlantic cod**, Gulf of Maine stock (regions 4 and 5 in Massachusetts waters), exhibited relatively high values during the first few years of the time series. The index dropped in 1984 and remained below the median through the mid-1980s, then increased to a relative high in 1989-1990. The index then declined steadily to a time series low in 1997. Since 1997, the index has increased significantly, attaining a time series high in 2000. In 2001, the index remained at a very high level, matching the 2000 high. These highs were followed in 2002 by a slight decline in the index, although it remains at nearly twice the time series median and represents the sixth highest value in the time series.

From the start of the survey in 1978 until the early 1980's the **yellowtail flounder** biomass index for the Cape Cod stock (regions 3-5) remained relatively high. However,

a steady decline from a 1981 peak led to 10 years (1985-1994) at or below the time series median. A modest and unsustained increase was seen in the mid 1990s. In 2000, the index increased dramatically to more than three times the median. The 2000 time series high was followed by a slight decrease in 2001 but the index remained well above the median. A significant decrease was seen in 2002, with the index declining to a value very near the time series median.

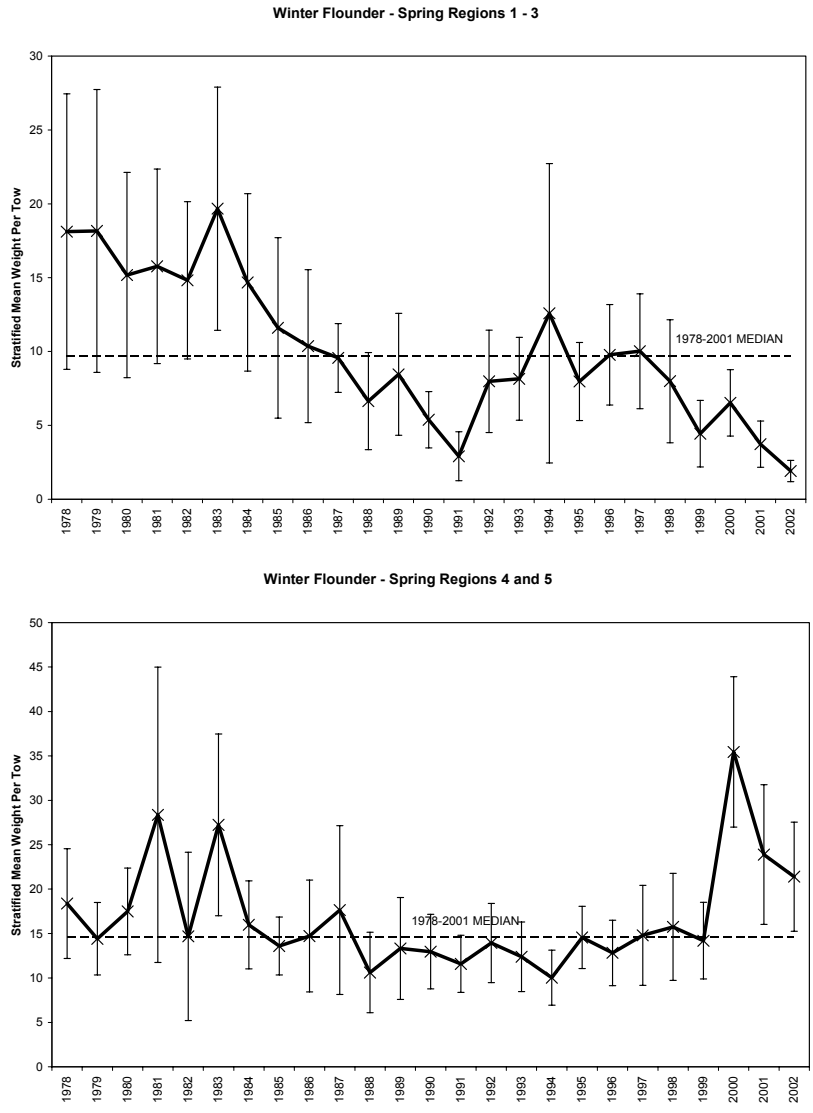


Figure 8. Winter flounder spring abundance.

The **winter flounder** index for the southern New England stock (regions 1-3) was at a high level from 1978-1983 before declining, almost uninterrupted, to lows in the late 1980's and early 1990s. Through the mid-1990s the index fluctuated around the median. In the late 1990s through 2001, the biomass indices declined to values similar to lows recorded a decade earlier. This decline continued in 2002, with the index reaching the lowest value seen in the time series.

For assessment purposes, the *MarineFisheries* MA DMF **winter flounder** biomass index for regions 4-5 is the *de facto* fisheries independent estimator for Gulf of Maine winter flounder. Spring biomass values decreased after 1983. The index remained at or below the median with no perceptible trend from 1988 through 1994. A slight increasing trend in the latter half of the 1990s was followed by a dramatic rise to a time series high in 2000. In 2001, the index dropped from the record of 2000 but remained higher than any of the previous sixteen years. The index continued to decline in 2002, yet remained well above the median, and represents the fifth highest index in the time series.

The spring **black sea bass** index (regions 1-3) was high from 1978-1983 then declined to record-lows from 1992-1998. The biomass remained below the median from 1987-1998 followed by an increase to a record high in 2000. The index declined somewhat in the subsequent two years, but remains well above the median. The three terminal years, 2000-2002, combined to produce the highest 3-yr average in the time series. The *MarineFisheries* biomass trend agrees with Massachusetts landings over the past decade

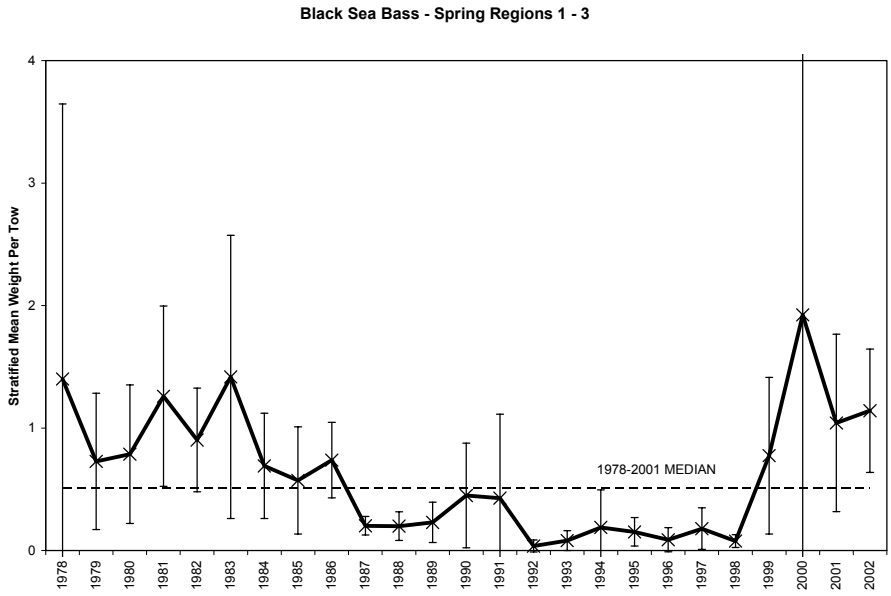


Figure 9. Black sea bass spring abundance.

(Caruso 2002).

The spring **tautog** index (regions 1 – 2) exhibited an increasing trend in the early years of the survey, culminating in a time series high in 1986. The index then declined over the next few years, dipping below the median in 1990. The index has remained at low levels since that time and has been well below the median since 1992.

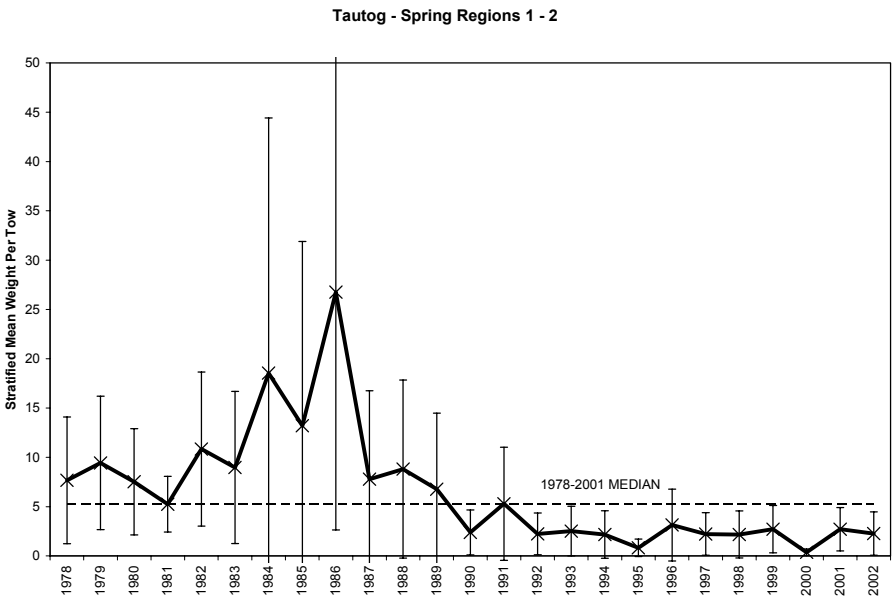


Figure 10. Tautog spring abundance.

The spring **summer flounder** biomass index (regions 1 - 3) declined after 1982. For a period of eight years (1986-1993), the index remained below the median and a time series low was measured in 1991. Since

that time, the index has generally exhibited an increasing trend. In eight of the past nine years (1994-2002), the biomass index has been above the median. Following a relative low in 1996, the index rose steadily to a record high in 2000. The 2001 index declined over 30% from 2000 yet was still one of the highest values in the time series. A slight increase was seen in 2002 with the index representing the second highest in the survey time series (more than two times the median). The recent *MarineFisheries* index trend mirrors that of the NEFSC spring survey and, over the time series, resembles the trends in spawning stock biomass derived for the Middle Atlantic-Georges Bank stock region

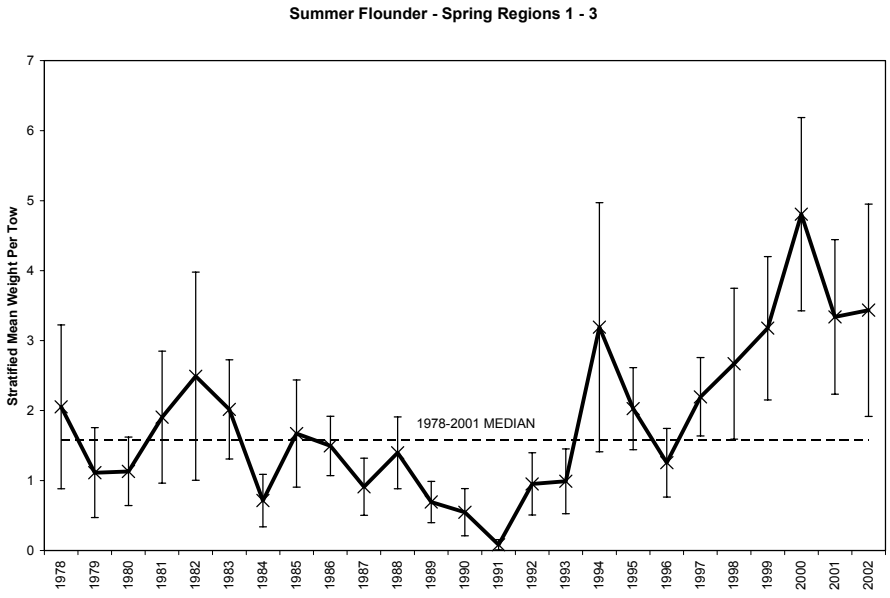


Figure 11. Summer flounder spring abundance.

(NEFSC 2000).

The **long-finned squid** index (spring, regions 1 - 3) reveals a period of relatively low and variable biomass from 1978-1982 followed by nine years in which the index remained above the median (1982 – 1991). For the past decade, the index has remained at low levels, with nine of the past eleven years below the time series median.

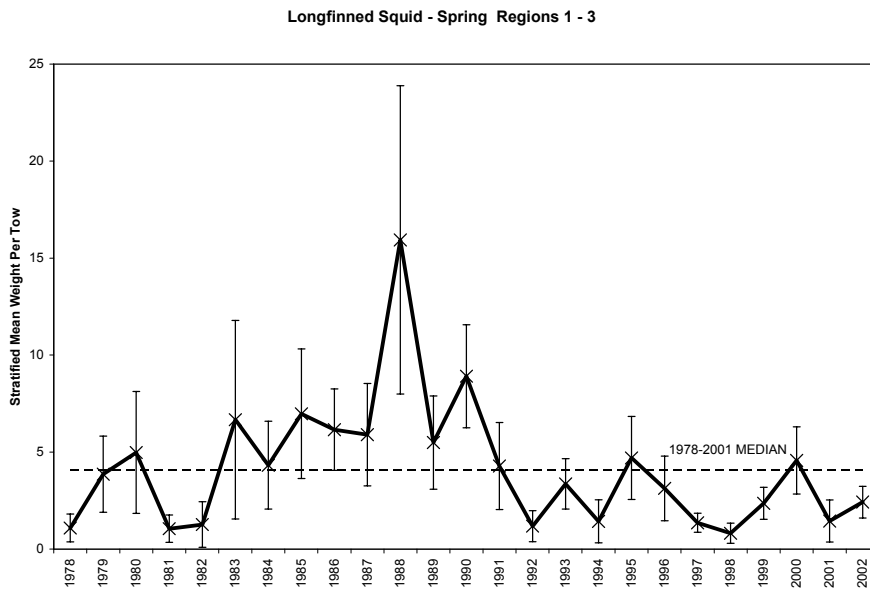


Figure 12. Long-finned squid spring abundance.

The spring **scup** biomass index (regions 1-3) was at its highest values in the early years of the survey time series (1978-1981). From 1982 to the present, the index has remained

significantly lower except for single year highs in 1990, 2000 and 2002. A decline from a relative high in 1990 to record lows from 1996-1998 is apparent. This decline has been followed by more variable (and generally greater) catch rates in recent years. The 2002 index was more than five times the median and represents the sixth highest value in the time series.

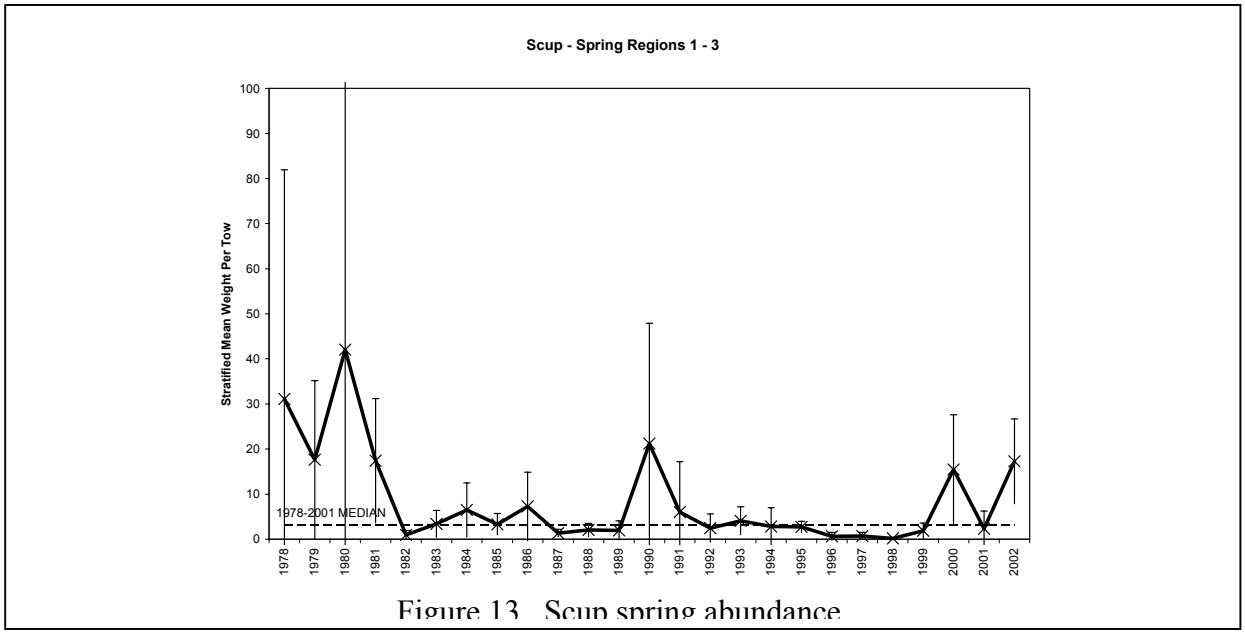


Figure 13. Scup spring abundance

Butterfish are captured in great numbers during autumn surveys in state waters south of Cape Cod (regions 1 and 2). The bulk of the biomass captured represents recent year classes (ages 0 and 1) with few older fish present in catches. Therefore, this index may serve as an indicator of year-class strength as well as stock biomass. The autumn butterfish index has varied greatly over the time series, with periods of high biomass interspersed with periods of low biomass. The early years of the survey are characterized by relatively low biomass levels. From the late 1980's through the late 1990s the index exhibited a general increasing trend with the majority of years above the median. This increase led to a time series high in 1998. This high was followed by a dramatic decline to values near the median. The terminal year shows a slight increase in biomass.

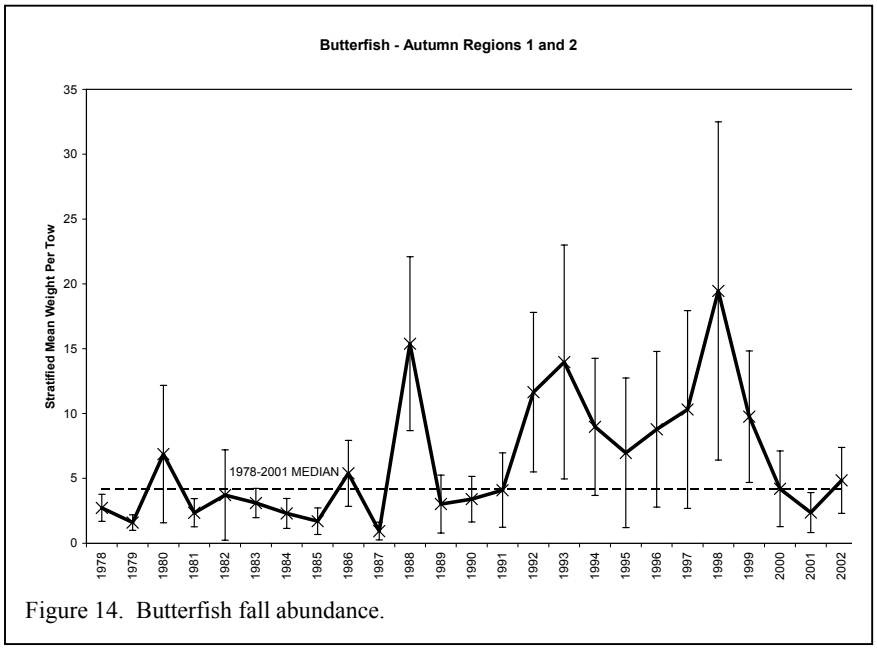


Figure 14. Butterfish fall abundance.

Limitations of the RAP Trawl Survey

- Seasonality – The RAP survey samples only those species available in May and September.
- Habitat – Due to the nature of the sampling gear, "hard bottom" habitat is undersampled.
- Habitat utilization – The data provide little information concerning species abundance as it relates to habitat type.
- Species represented – The RAP survey gear does not sample pelagic and semi-pelagic species well, and other fish species have low catchability related to the sampling gear.
- Estuaries/nearshore – Due to vessel size, very shallow water (< 7 meters) is not well sampled.

WINTER FLOUNDER YOUNG-OF-THE-YEAR (YOY) SEINE SURVEY

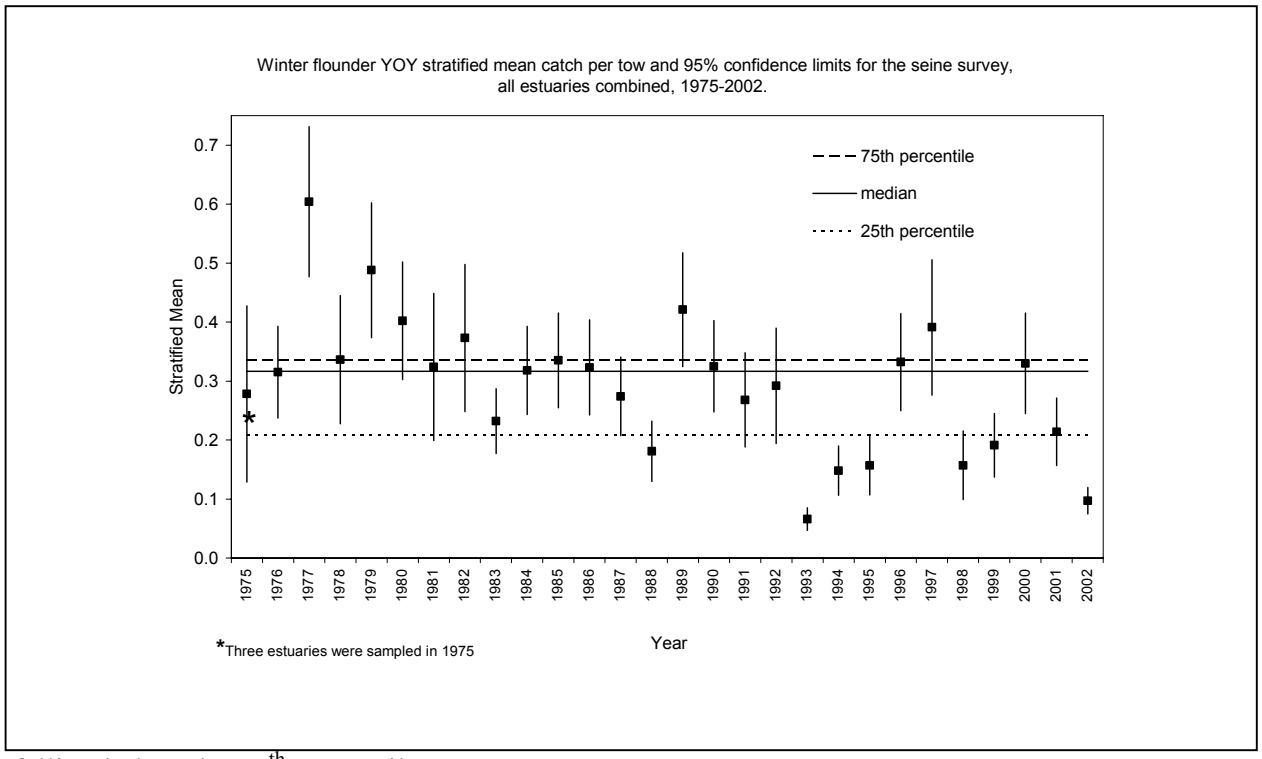
Since 1975, *MarineFisheries* has conducted a seine survey of six Cape Cod south shore estuaries (Bass River, Cotuit Bay, Great Pond, Lewis Bay, Stage Harbor, and Waquoit Bay) during the months of June and July. The survey's primary objective is to assess winter flounder YOY cohort abundance (i.e., the southern stock). The survey also enumerates YOY summer flounder and 'brit' (juvenile) Atlantic herring since both data sets are monitored by assessment working groups as potential predictors of recruitment. Preliminary sampling efforts also included Buzzards Bay and areas north of Cape Cod; however, these stations were discontinued due to insufficient agency resources.

Survey Design

Seining of intertidal and shallow subtidal zones occurs from two hours before to two hours after high tide. Forty-nine stations, chosen for efficient seining (i.e., smooth sediment bottom generally devoid of attached vegetation) and historic availability of YOY (also categorized as 0-group) winter flounder, were proportionately allocated by each estuary's (stratum) littoral perimeter. A 6.4-meter straight seine of 6.4 mm nylon meshes and equipped with weighted lead line footrope is hauled perpendicular to shore from depths of up to approximately 1.2 meters. To enumerate 0-group winter flounder density (# YOY per square meter), three replicate hauls at each station are quantified to area swept by maintaining a taut spreader rope, and pacing seining distance. Statistical analysis of the seine data employs stratification techniques; each estuary is considered a stratum, and the three replicate hauls at each station are treated as one sample. Stratified mean density and confidence limits are derived from standard and modified formulas for mean and variance.

Time-Series Trends of YOY Winter Flounder

The seine survey index for YOY winter flounder exhibits considerable variability from year to year, although trends are apparent in the time-series. During the early years of the survey, the mean catch per tow was generally at or above the time-series median, with a number of years well above the 75th percentile. In the 1980's the index generally tracked close to the median. During the last decade the index indicates generally low recruitment, with seven of the last 10 years below the median and six of those years



falling below the 25th percentile.

Limitations of the YOY seine survey

- Species – This is primarily a single species survey and provides little information on other important estuarine species.

- Geographic Coverage – Due to manpower limitations, only six estuaries are sampled. There are numerous others with potential for significant production of YOY winter flounder, which could potentially influence the index.

2) Coastal Lobster Investigations

MarineFisheries' Coastal Lobster Investigations Project employs a comprehensive four-tier approach to monitoring lobster populations in Massachusetts coastal waters. This approach includes two fishery dependent monitoring programs, the Massachusetts Coastal Commercial Lobster Trap Sampling Program and Lobster Fishery Statistics Program, as well as two fishery independent programs, the Inshore Bottom Trawl Survey (described in previous section) and the Early Benthic Phase (EBP) Suction Sampling Survey.

COMMERCIAL LOBSTER TRAP SAMPLING PROGRAM and MASSACHUSETTS LOBSTER FISHERY STATISTICS

Initiated in 1981, the Commercial Lobster Trap Sampling Program was and is the cornerstone of monitoring lobster populations in Massachusetts coastal waters. The program is a cooperative effort between commercial lobster fishermen and *MarineFisheries* designed to collect biological and catch per unit effort data with sufficient precision for stock assessments. Sampling is carried out twice a month from May through November, coast-wide in each of six regions (Figure 16), during the normal

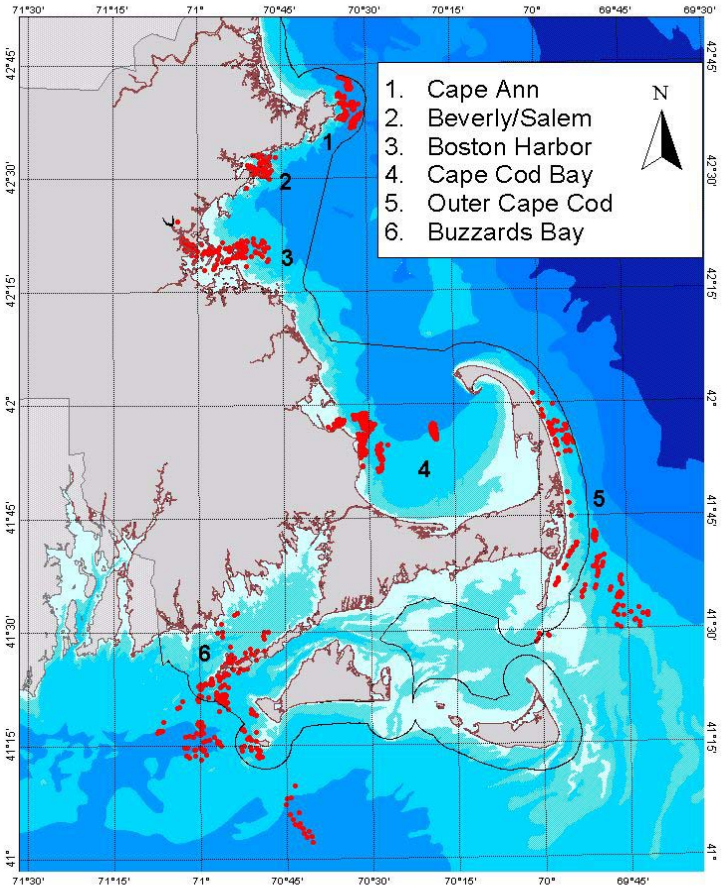


Figure 16. Map of coastal Massachusetts with trap/trawl locations sampled in 2002 throughout six sampling regions.

lobstering operations of volunteer commercial lobstermen.

Sea samplers use portable cassette tape recorders to record carapace length (to the nearest mm), sex, and condition, including the degree of shell hardness, culls and other shell damage, external gross pathology, mortality, and presence of extruded ova (eggs) on females (ovigerous) for every lobster that is caught. Catch in number of lobster, number of trap hauls, set over days, trap and bait type are also recorded. Since the early 1990s, *MarineFisheries* has also monitored the prevalence and spatial distribution of lobster shell disease. Trap locations are recorded from LORAN/GPS instruments on each vessel and plotted on nautical charts. Depth information is estimated from NOAA navigational charts as a coast-wide standard to avoid variability from tidal fluctuations. Data generated from this program are utilized as an integral part of the ASMFC stock assessment process, specifically for calculating fishing mortality rates and egg per recruit estimates.

In 2002, the coast-wide mean catch per unit effort index (catch per trap per three set over days; CTH'3) of 0.823 marketable lobster per trap was 3.8% higher than the time series mean of 0.793. Total Massachusetts commercial landings, 13,373,809 lbs, increased by 9.8% from 2001. Landings from territorial waters, 8,083,603 lbs, increased by 13% from 2001 (Figure 17). The coast-wide mean catch rate of sublegal lobster, 0.23 lobsters per trap haul, is the third lowest in the time series, and has remained below the time series mean (0.489) since 1994. It should be noted that escape vent sizes increased during this period, which may in part account for the reduced catch of sublegal lobster.

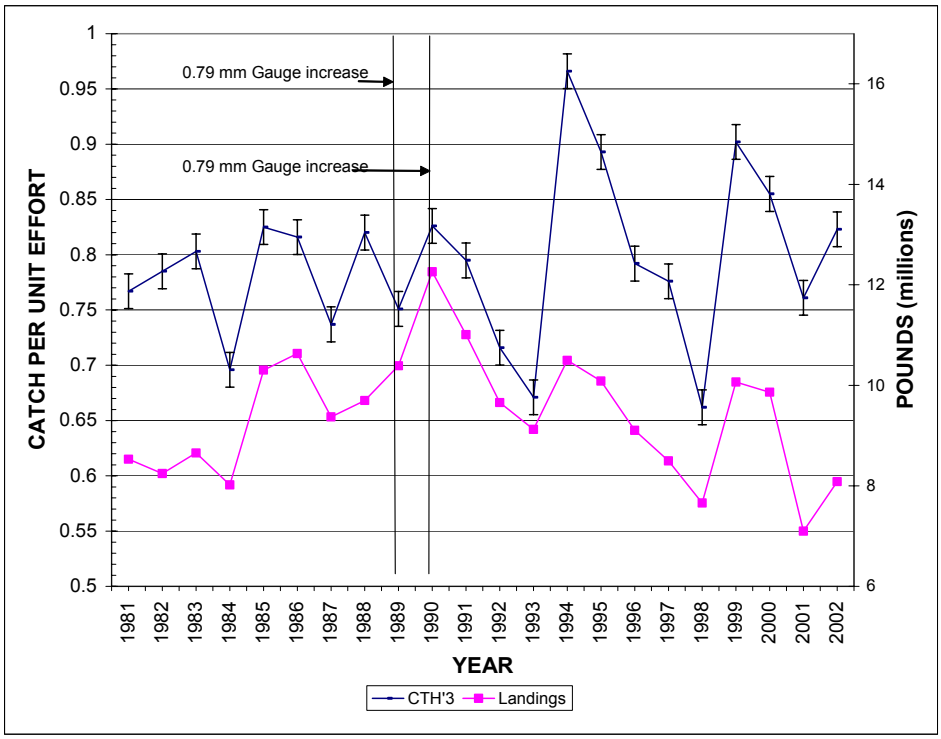


Figure 17. Catch per unit effort (catch per trap per three set over days; CTH'3) of marketable American lobster fro commercial trap sampling and Massachusetts lobster landings from territorial waters, 1981 - 2002.

Historical landings data in Massachusetts provide a perspective on the current condition of the fishery and recent catch trends (Figures 18 and 19). Annual Massachusetts coastal landings (excluding data from beyond territorial waters), which were available only in number of lobster between 1888 and 1921, generally declined between 1888 and 1917 then gradually increased through 1921 (Figure 18). Subsequent landings, available in lbs., doubled over the 52-year time span between 1922 and 1974. Major increases in traps and landings occurred between 1975 and 1990. These trends in landings were primarily a

reflection of nominal fishing effort (total traps fished); however, they cannot be attributed to greater fishing effort alone. Total lobster landings and effort from all lobster harvesting states also increased between the late 1970s and 1990s; however in the Canadian Maritimes, where trap limits and license restrictions exist, landings also increased implicating an environmental influence on lobster abundance.

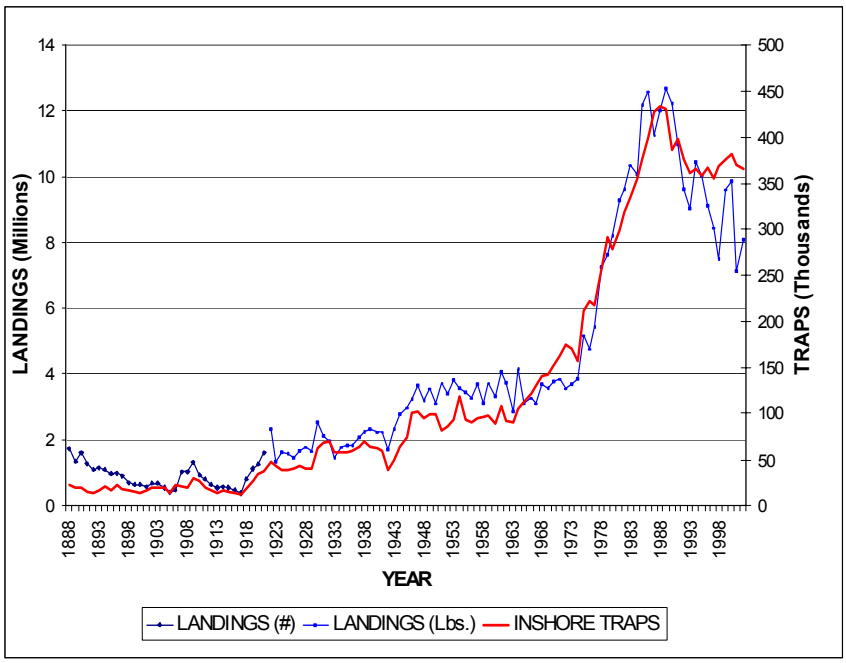


Figure 18. American lobster landings and traps fished from Massachusetts territorial waters, 1888-2002. Data are from MA Lobster Fishery Statistics Program.

Since 1990, Massachusetts inshore lobster landings have declined dramatically and while nominal effort has also decreased, the close correlation evident through the early 1990s has not been maintained.

The average annual pounds per trap (annual landings/total traps fished) experienced a steep decline in the Massachusetts inshore fishery from the beginning of the time series until the early 1900's. Through the first half of the 1900's the annual catch per trap varied without trend, but underwent another significant decline in the 1960's (Figure 19). Between 1970 and 2002 this index ranged between 20 and 30 lbs. per pot, with the two lowest values in the time series (20.4 and 19.3 lbs. per pot) occurring in 1998 and 2001 respectively.

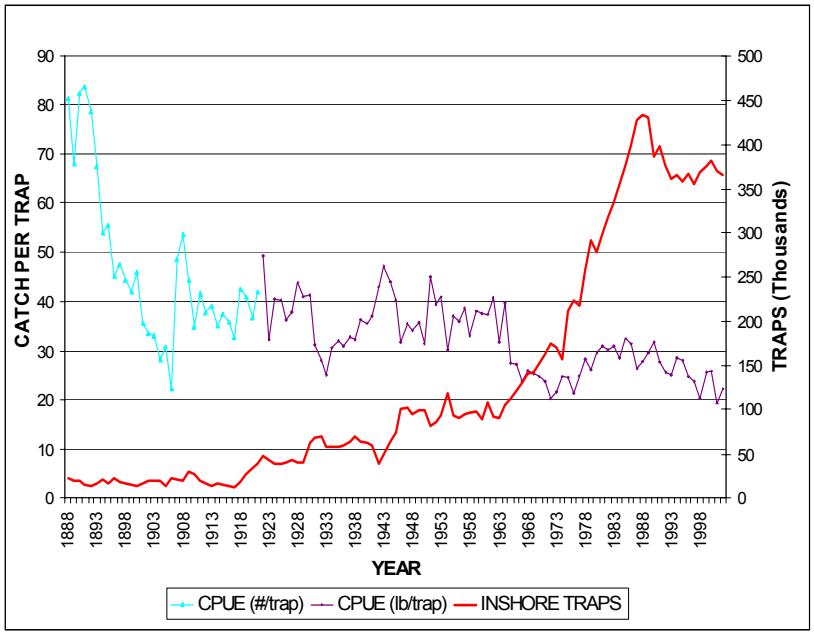


Figure 19. Traps fished and catch/trap data from Massachusetts territorial waters, 1888-2002. Data are from MA Lobster Fishery Statistics Program.

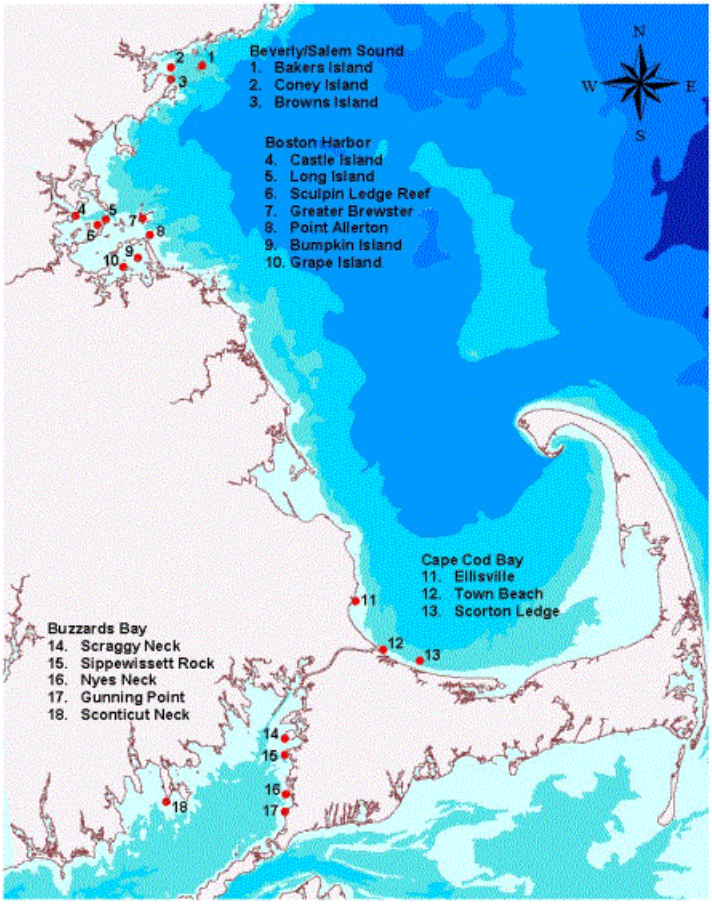


Figure 20. *MarineFisheries* EBP sampling station locations along the coast.

EARLY BENTHIC PHASE LOBSTER MONITORING

An annual sampling effort for Early Benthic Phase (EBP) or juvenile lobsters is conducted by SCUBA through suction sampling of 1/2 square meter plots in order to generate density indices of newly-settled post-larval lobsters (1995 to present) and larger juveniles, and to delineate coastal habitat important to the settlement of these juveniles, in particular cobble bottom. Work is conducted annually in four coastal regions (Figure 6), off Salem (3 sites), Boston (7 sites), Cape Cod Bay (3 sites), and Buzzards Bay (5 sites). Other macro-invertebrates (i.e., crabs) encountered are enumerated through this effort.

MASSACHUSETTS RESOURCE ASSESSMENT PROJECT INSHORE BOTTOM TRAWL SURVEY – LOBSTER ABUNDANCE INDICES

Southern Gulf of Maine (MA southern GOM): Relative abundance trends from *MarineFisheries'* inshore bottom trawl surveys indicate that catch per unit effort (CPUE) has declined to a level similar to that observed in the early 1980's or lower. The 2001 MA southern GOM fully-recruited (83+mm carapace length, CL) lobster indices were well below their respective time series means, and were close to the lowest values in the 21-year time series for both males and females. The 2001 MA GOM pre-recruit (71-82mm CL) lobster indices were well below their respective time series means, and were the second lowest values in the 21-year time series for both males and females. The 59-70 mm CL size group followed a similar trend for both sexes.

Southern New England: The 2001 Massachusetts Southern New England fully-recruited (83+mm CL) lobster indices were well below their respective time series means for both males and females. The pre-recruit (71-82mm CL) indices, declining since 1991, were near time series lows, and have remained well below that observed in the late 1980's and early 1990s for both sexes. The 59-70 mm CL size group followed a similar trend for both sexes, peaking in 1993 then declining thereafter.

BOTTOM WATER TEMPERATURE MONITORING

In conjunction with the coastal lobster monitoring investigations, *MarineFisheries* has monitored bottom water temperature from 1982 to present. Water temperature is collected with programmable electronic recorders at various depths at nine coastal sites located north and south of Cape Cod. *MarineFisheries* is concerned with the impact of increasing water temperatures on lobster along the Massachusetts coast. Conclusions on the effect of temperature on lobster abundance are yet to be determined. See Water and Sediment Quality Technical Report for further description.

3) Nearshore Embayment Studies of Marine Resources

During the 1960's and 1970's, *MarineFisheries* conducted a series of studies in the sixteen major embayments along the Massachusetts coast. These studies were designed to characterize the living resources within each embayment with an emphasis on finfish, decapod crustaceans, and commercially-important shellfish. The embayments covered include: Merrimack River, Parker River-Plum Island Sound, Gloucester Harbor-Annisquam River, Beverly-Salem Harbor, Lynn-Saugus Harbor, Dorchester Bay, Quincy Bay, Hingham Harbor, North River, Plymouth-Duxbury Bay, Wellfleet Harbor, Pleasant Bay, Bass River, Waquoit Bay-Eel River, Westport River, and Taunton River-Mt. Hope Bay.

One of the more noteworthy results of this effort was the illustration of the tremendous biodiversity of estuarine fauna found along the Massachusetts coast. Over the last 30-40 years, these reports have provided a great deal of information for management of our coastal resources and the review of coastal alteration projects. In many cases, they remain the only source of information regarding living marine resources in specific areas. While they continue to be very valuable sources of information, that information is now outdated because of changes in the living marine resources resulting from changing land and water use, exploitation of many fish and shellfish species, and natural population fluctuations. Due to budget and personnel constraints within *MarineFisheries*, only one of these studies has been repeated by *MarineFisheries*. The study of Beverly-Salem

Harbor was updated in 1997 and has been published in the *MarineFisheries* Technical Report Series (No. TR-6). This study documented a number of changes that have occurred in this estuary, notably a general improvement in the condition of the area and a change in the rank abundance for several species. *MarineFisheries* assisted the Office of Coastal Zone Management study fishes and decapod crustaceans in Gloucester and New Bedford Harbors and Massachusetts Audubon investigated the marine resources of the Parker River – Plum Island Sound estuary. Although the CZM and Massachusetts Audubon studies are not directly comparable to the 1960's and 1970's studies, they provide the first comprehensive examination of marine resources in these embayments since the initial assessments.

It is critical that these studies be repeated in all of Massachusetts important embayments, so that they may once again serve as a primary source of information for responsible management of Massachusetts coastal living resources.

4) Anadromous Fish

MarineFisheries informally monitors the spawning runs of anadromous fishes in Massachusetts in over fifty separate locations through direct observation and through information provided by local officials and watershed groups. *MarineFisheries* staff directly enumerate fish at several locations using a variety of methods including electronic counters and visual counts. The longest time series of information is available for the Herring River in Bournedale (Figure 21) and for the Merrimack River in Lawrence (Figure 22). The river herring population in the Herring River has shown wide fluctuations with declines in 2002 and 2003. In the Merrimack River, the river herring run has declined in recent years but the American shad population has increased

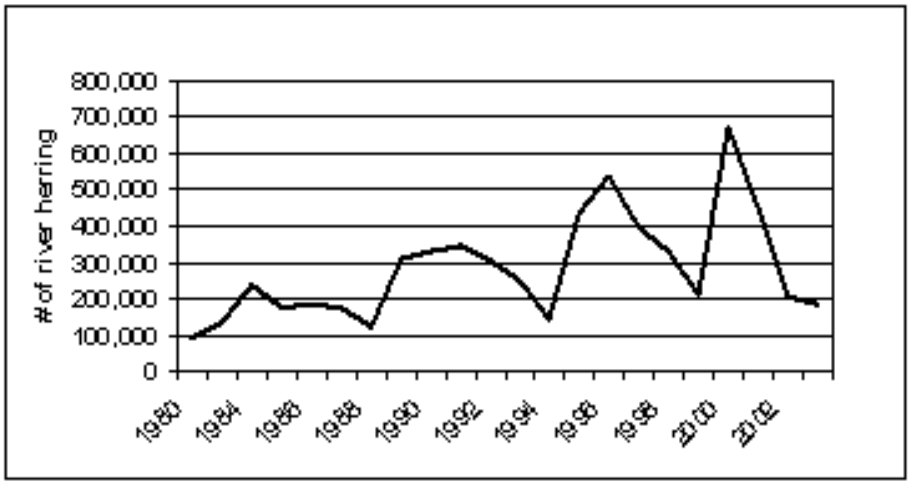


Figure 21. River herring counts on the Herring River, Bournedale, MA.

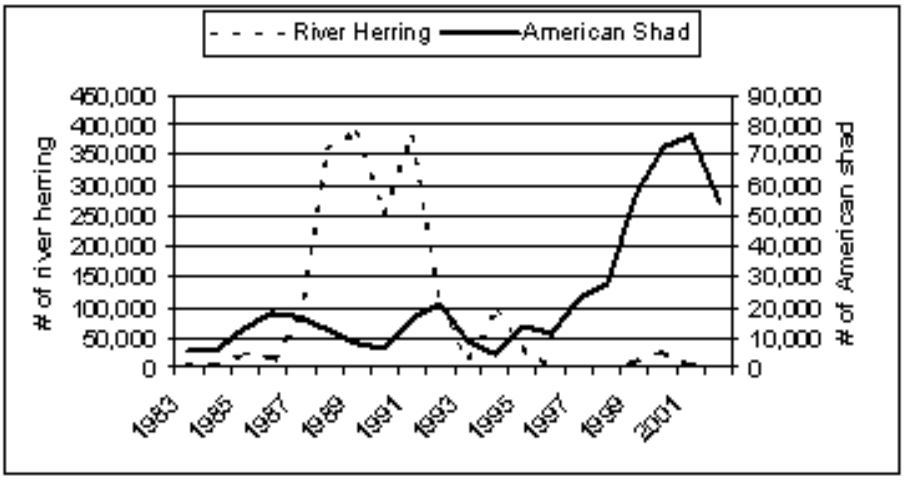


Figure 22. River herring and American shad counts on the Merrimack River.

dramatically.

The Anadromous Fish Program also monitors and maintains the function of fish passage structures throughout coastal Massachusetts. A recent survey of fish passage (Massachusetts Division of Marine Fisheries Technical Reports TR-15 through TR-18) recorded 175 fish passage structures and over 100 separate runs of anadromous fish. Historically, anadromous fish were eliminated from most of the coastal rivers and streams. Through stocking and fishway construction over the last 50 years, *MarineFisheries* has restored anadromous fish populations to many of our coastal water bodies. Continued restoration of the anadromous fish resource will require extensive repairs and maintenance to existing infrastructure as well as continued stocking, research, and fishway construction.

5) Tournament Monitoring of Large Pelagic Fishes

The highly migratory nature, large size, and long life span of species such as bluefin, yellowfin, albacore, and bigeye tunas, blue, mako, and thresher sharks, and blue and white marlin render data acquisition and biological studies that are expensive and difficult to execute. Consequently, recreational fishing tournaments have been used as a tool by *MarineFisheries*' biologists to learn about the species and size composition, basic biology, and relative abundance of big game fishes off our coast. Offshore fishing tournaments not only provide catch data and biological samples but estimates of effort, which are often lacking for offshore recreational fisheries. Although the number of tournaments held in Massachusetts fluctuates from year to year, there are generally eight to eleven, with most located on the Cape and Islands. While some target a single species or type of fish, like sharks or giant bluefin tuna, most tournaments offer prizes for a variety of species. All the events self-impose minimum sizes and bag limits (i.e., maximum number of fish landed allowed) while promoting tag and release, so points can be garnered by not only weighing fish but by also releasing them.

Although tournament data are traditionally used by the federal government to monitor landings in offshore recreational fisheries, the Massachusetts Tournament Program is unique. The *MarineFisheries* program makes every effort to collect total catch information, which includes not only fish that are landed but also those that are tagged, released, or lost. By working closely with tournament sponsors and tournament participants, *MarineFisheries* biologists not only assist in the development of the event but also facilitate complete data collection. This is particularly important when indices of abundance are used to monitor annual changes in fishing success.

The fishing effort collected at each tournament are used to calculate catch per unit effort or CPUE. For tournament fishing CPUE is defined as the number of fish caught for each hour fished. Dramatic fluctuations in CPUE may be indicative of changes in regional fish abundance caused by corresponding changes in prey availability, fish population size, or the environment. Program personnel analyze long-term trends in CPUE and summarize these findings in an annual program report.

The Massachusetts Sportfishing Tournament Monitoring Program also collects catch data at the month-long Martha's Vineyard Striped Bass and Bluefish Derby. These data allow for the delineation of trends in the inshore abundance of striped bass, bluefish, false albacore, and Atlantic bonito. The comprehensive catch and effort data collected by the Tournament Program are forwarded annually to the National Marine Fisheries Service for inclusion in their national statistics.

Sharks in the coastal waters of Massachusetts

MarineFisheries established the Massachusetts Shark Research Program (MSRP) in 1989 to characterize the ecology, distribution, and relative abundance of sharks subjected to fisheries off the coast of Massachusetts. The MSRP conducts angler and longline surveys and collects information from recreational and commercial fishers. Biological parameters including age structure, feeding ecology, local movements, and reproductive status are examined through dissection and tagging of shark specimens. Additionally, information has been compiled and analyzed for the identification of primary and secondary shark nursery habitat in the coastal waters of Massachusetts.

The Massachusetts coastline is divided by Cape Cod into two general areas relative to shark nursery habitat. The major coastal water masses south of Cape Cod include Buzzards Bay, Vineyard Sound, and Nantucket Sound, while Cape Cod Bay and Massachusetts Bay are the major coastal water bodies north of Cape Cod. This landmass represents the northern limit to the geographic range of a few coastal shark species, which include the smooth dogfish (*Mustelus canis*), sandbar shark (*Carcharhinus plumbeus*), dusky shark (*Carcharhinus obscurus*) and tiger shark (*Galeocerda cuvieri*). While a number of species are found seasonally both north and south of Cape Cod, those penetrating inshore waters include spiny dogfish (*Squalus acanthias*), sand tiger (*Carcharias taurus*), great white (*Carcharodon carcharias*), and basking (*Cetorhinus maximus*) sharks.

Smooth dogfish, *Mustelus canis*

From 1989 to 2002, the MSRP examined 540 smooth dogfish caught by the longline (337) and angler (82) surveys, taken during other *MarineFisheries* sampling programs (82), and provided by commercial fishermen (39). These sharks were mostly sampled from the neritic waters of Chappaquiddick Island and Cape Poge Bay (424), but samples also came from other parts of Nantucket Sound. The size range of all smooth dogfish sampled by the MSRP was 27.5-121 cm fork length (FL; Figure 23). Based on published estimates of size at birth and size at maturity, the smooth dogfish sampled from Massachusetts waters comprised primarily newborns and adults. In the northern end of its range, the smooth dogfish moves into the neritic waters of Nantucket Sound, Vineyard Sound, and Buzzards Bay and associated estuaries in late May and early June to give birth. These areas, therefore, provide important primary nursery habitat for this species. Based on the size of neonates and time of capture, it is likely that parturition (birth) occurs in June and July in

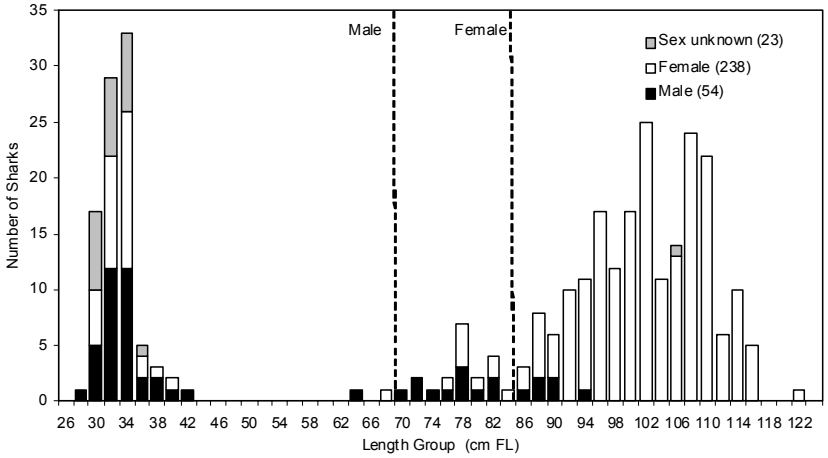


Figure 23. Length frequency distribution of smooth dogfish, *Mustelus canis*, sampled by the MSRP, 1989-2002; size at sexual maturity shown for each sex (dotted lines).

Massachusetts waters. *Mustelus canis* is a seasonal migrant and generally remains in inshore Massachusetts waters until October when it moves offshore and south.

Sandbar shark, *Carcharhinus plumbeus*

During the period of 1989 to 2002, 235 (88 males, 63 females, 84 unknown) sandbar sharks were examined or reported to the MSRP (Figure 24). Although sandbar sharks were taken between 21 June and 2 October, the species was most abundant in July. The size range of those sharks measured was 61-157 cm FL with no sexual differences (Figure 24). With a size at maturity of 143 cm FL and 149 cm FL for males and females, respectively, only 5% of the males and 2% of the females sampled over the 13-year period were mature. Thus, the majority of sandbar sharks occurring inshore are juveniles utilizing these areas as secondary nurseries. Sandbar sharks move out of Massachusetts coastal waters in early October, which likely coincides with seasonal cooling of inshore waters.

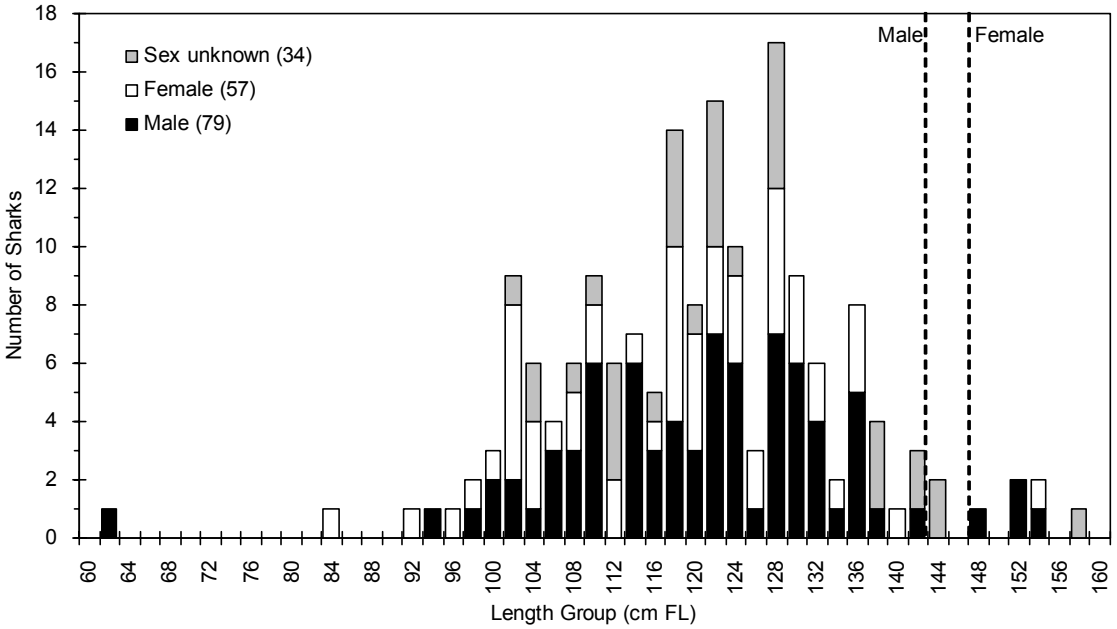


Figure 24. Length frequency distribution of sandbar sharks, *C. plumbeus*, sampled by the MSRP, 1989-2002, size at sexual maturity shown for each sex (dotted lines).

Dusky shark, *Carcharhinus obscurus*

From 1989 to 2002, only five dusky sharks have been sampled by the MSRP and these were taken on longline. Of the four reliably measured, three (two females, one male) were in the size range of 173-183 cm FL and one female was 254 cm FL. The three smaller *C. obscurus* were immature and the larger female had reached maturity. Although there are published reports of dusky sharks from Massachusetts coastal waters south of Cape Cod, the species is not common in southern New England. Nonetheless, this region may provide secondary nursery habitat to those dusky sharks that venture north.

Sand tiger shark, *Carcharias taurus*

Ten sand tiger sharks have been reported to the MSRP since 1989 and all were caught from August to October. The sand tiger shark was once considered the most abundant

large shark in Massachusetts coastal waters; it was exploited in Nantucket Sound in the early 20th century. Not a single adult sand tiger shark has been reported to the program since its inception in 1989, despite the extensive commercial and recreational fisheries (for other species) in this state. This provides evidence that intensive commercial fisheries can lead to the long-term depletion of local shark populations. The ten sand tiger sharks examined by the MSRP were reported from two general locations in coastal Massachusetts: south of Cape Cod in coastal waters off East Beach, Chappaquiddick Island (Martha's Vineyard) and from bays and estuaries in Massachusetts Bay (Salem Sound and Boston Harbor). All of these were small immature sand tigers in the size range of 87-132 cm FL; the five sexed were all female. In the western North Atlantic, the sand tiger gives birth from December through March and the average length at birth is 85.3 cm FL. Thus, five of the sand tigers sampled by the MSRP were 87-91 cm FL, close to or in their neonatal stage. These data indicate that the coastal waters of Massachusetts provide secondary nursery habitat for sand tiger sharks that move north from southeastern pupping grounds (habitat for juvenile sharks).

Great White Shark, *Carcharodon carcharias*

The great white shark is a seasonal migrant to the coastal and offshore waters of New England and each year the MSRP fields anecdotal reports of white sharks, which in most cases are misidentified. Published information on the distribution of the white shark in the western North Atlantic indicates that this species is most abundant in the Mid-Atlantic Bight on the continental shelf between Cape Hatteras, North Carolina and Cape Cod, Massachusetts. Moreover, more young white sharks have been caught in this area than in any area of comparable size in the world. In August 2002, a small great white shark (ca. 109 cm FL) was captured in a trawl net (between the Elizabeth Islands and Martha's Vineyard) and reported to the MSRP. Prior to this, two small white sharks were reported from this region, one harpooned off Boston in 1948 (ca. 81 cm FL) and one netted off Rhode Island in 1939 (ca. 138 cm FL). Length at birth of the white shark is estimated to be 108.0-136.0 cm FL. Therefore, these small white sharks were among the smallest reported free-swimming white sharks and clearly young of the year animals. It is likely that *Carcharodon carcharias* uses the neritic waters of the Mid-Atlantic Bight including the coastal waters of Massachusetts as a secondary nursery area.

Basking Shark, *Cetorhinus maximus*

In the western North Atlantic, the basking shark is known to concentrate in the spring and summer in areas of high productivity and along thermal fronts on the continental shelf from southern New England to Newfoundland. The basking shark is well documented off the coast of Massachusetts and basking shark reports to the MSRP have ranged from the coastal waters of Buzzards Bay, Vineyard Sound, Cape Cod Bay, and Massachusetts Bay to the offshore waters of the Great South Channel and Stellwagen Bank. Very little is known of the size and age structure of the basking shark population in these waters, but it is thought to comprise juveniles and adults. From 1984 to 2003, seven stranded or incidentally captured basking sharks (three males, four females) were examined by the MSRP. Males ranged from 320-696 cm FL and females ranged from 310-690 cm FL. Two of the males and all four of the females were found to be immature. It is clear that the coastal and offshore waters of southern New England provide important secondary nursery habitat for this planktivorous species. The extent to which this region serves as primary nursery habitat is unknown because neonates and pregnant females remain elusive.

Tiger Shark, *Galeocerda cuvieri*

The tiger shark is generally reported from tropical and warm temperate waters of the western North Atlantic, but it is rarely encountered north of the Mid-Atlantic Bight. There are previous reports of juvenile tiger sharks in coastal waters south of Cape Cod, but from 1987 to 2002, the five tiger sharks recorded by offshore fishing tournaments were caught several miles south of Martha's Vineyard and Nantucket Islands. In June 2001, a juvenile female tiger shark (133 cm FL) was taken by a recreational fisherman off the southern shore of Martha's Vineyard. Although historically present, tiger sharks were rare in recent years as is their utilization of Massachusetts coastal waters for secondary nursery habitat.

Shark Fisheries

With the exception of trawl, gillnet, and longline fisheries that target spiny dogfish, *Squalus acanthias*, there are no directed commercial fisheries for sharks in Massachusetts. Of the 1,740 metric tons (MT) of sharks landed in the Commonwealth in 2002, 99% were spiny dogfish and the remaining 1% (15.8 MT) comprised pelagic sharks including shortfin mako (*Isurus oxyrinchus*), porbeagle (*Lamna nasus*), and blue (*Prionace glauca*) sharks taken incidental to offshore trawl, longline, and gillnet fisheries. However, a substantial recreational fishery for sharks occurs off the coast of Massachusetts from June through September each year. The most recent estimates from the National Marine Fisheries Service (NOAA Fisheries) Marine Recreational Fishery Statistics Survey (MRFSS) indicate that Massachusetts recreational fishers caught about 430,000 sharks in 2002, with spiny dogfish comprising 99% of the catch. The MRFSS estimates that the balance of the catch were blue and shortfin mako sharks as well as the smooth dogfish, *Mustelus canis*, and the sandbar shark, *Carcharhinus plumbeus*. Although Massachusetts recreational fishers target sharks, few are landed; MRFSS estimated that 82% of the 2002 catch was released.

Limitations of Shark Monitoring

There are indications that MRFSS data do not adequately reflect the extent to which sharks utilize the neritic waters of Massachusetts. Specifically, the survey does not fully represent species composition, fails to generate accurate indices of relative abundance, and does little to identify the temporal and spatial distribution of sharks and shark nursery habitat in these waters.

D) Shellfish Resources – Commercial Shellfisheries and Aquaculture

MARINEFISHERIES SHELLFISH SANITATION AND MANAGEMENT PROGRAM

The Shellfish Program has two primary missions, public health protection, and both direct and indirect management of the Commonwealth's molluscan shellfish resources. Public health protection is afforded through the sanitary classification of all 1,745,723 acres of overlying waters within the states territorial sea in accordance with the provisions of the National Shellfish Sanitation Program (NSSP). The NSSP is the federal/state cooperative program recognized by the U.S. Food and Drug Administration (FDA) and the Interstate Shellfish Sanitation Conference (ISSC) for the sanitary control of shellfish produced and sold for human consumption.

Shellfisheries management is accomplished by direct *MarineFisheries* regulation of the commercial surf clam, ocean quahog, and quahog dredge boat fisheries, harvest of contaminated shellfish for depuration and relaying, size and maximum harvest limits of other shellfish, bay scallop and conch seasons, shellfish aquaculture and collection of statistics. Indirectly, *MarineFisheries* manages through its partnership with the coastal cities and towns by providing technical assistance and consultation with local management authorities (elected officials and shellfish constables) in the development of management plans and local regulatory decisions.

COMMERCIAL AND RECREATIONAL SHELLFISH LANDINGS

MarineFisheries is charged with collecting, analyzing, and maintaining an historical database of commercial and recreational shellfish landings. This information is initially collected by each of the 65 coastal cities and towns of the Commonwealth and submitted annually on "Town Landings" forms. Data collected reflects the number and types of permits issued, the pounds of each species landed and by what shellfishing methods. Along with data, the municipalities submit updates of their local shellfishing regulations. These data have been maintained since 1955 in both hard copy and electronic format and is used for fisheries management on the local, state, and federal levels. The following graphics present 2002 coast-wide Massachusetts landings for selected species by statistical reporting areas (Figures 25 – 27).

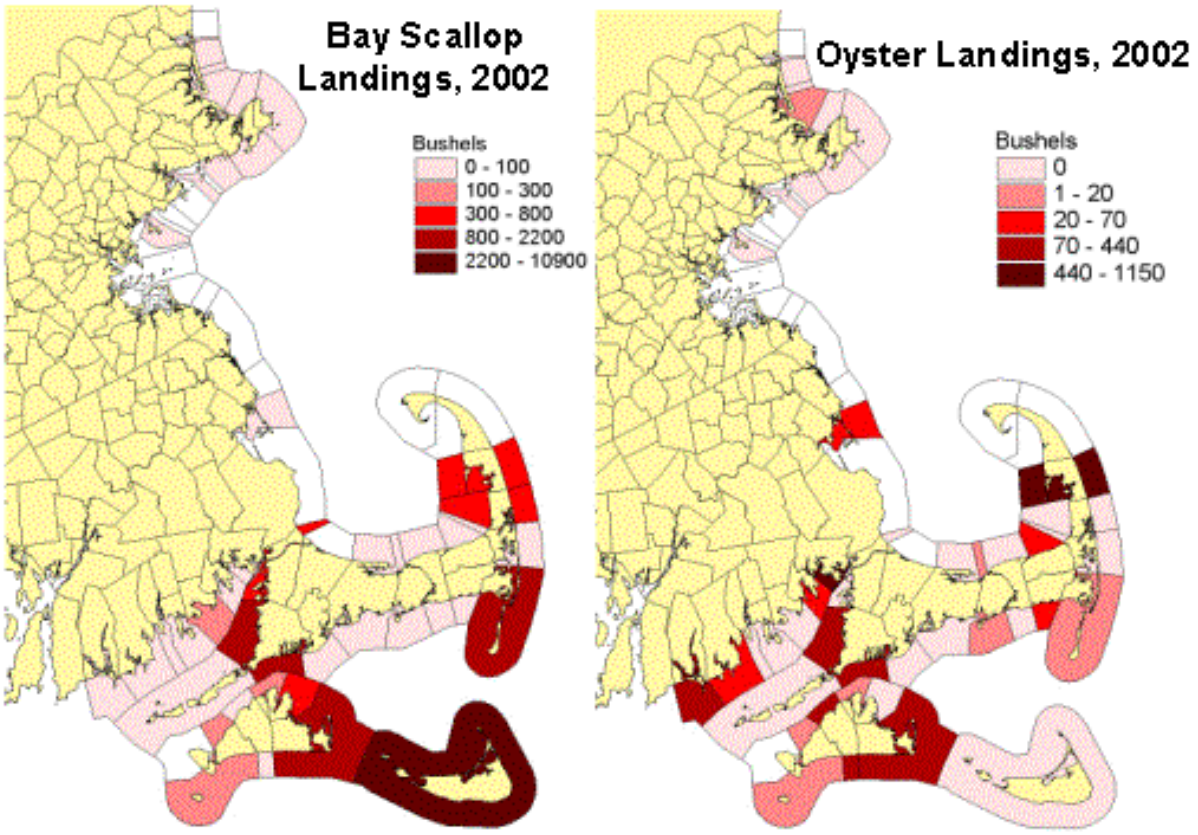


Figure 25. Bay scallop and oyster landings for Massachusetts in 2002.

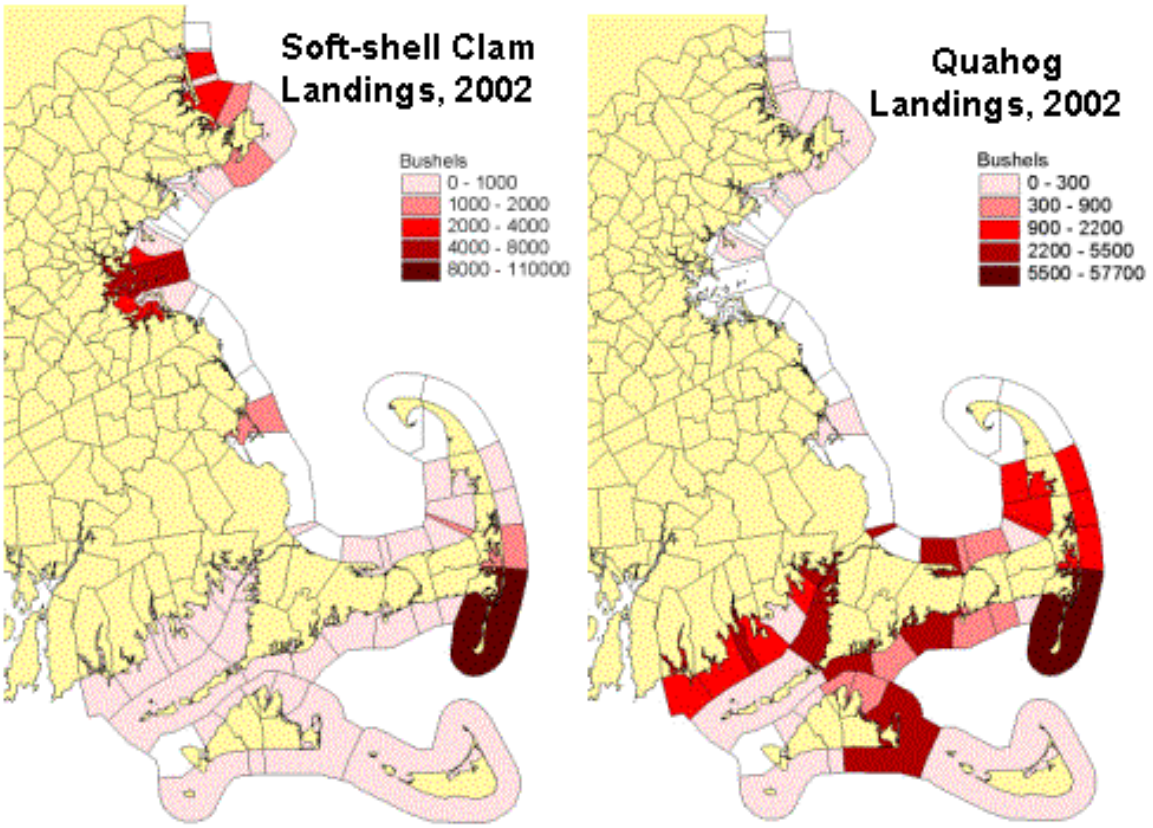


Figure 26. Soft-shell clam and quahog landings for Massachusetts in 2002.

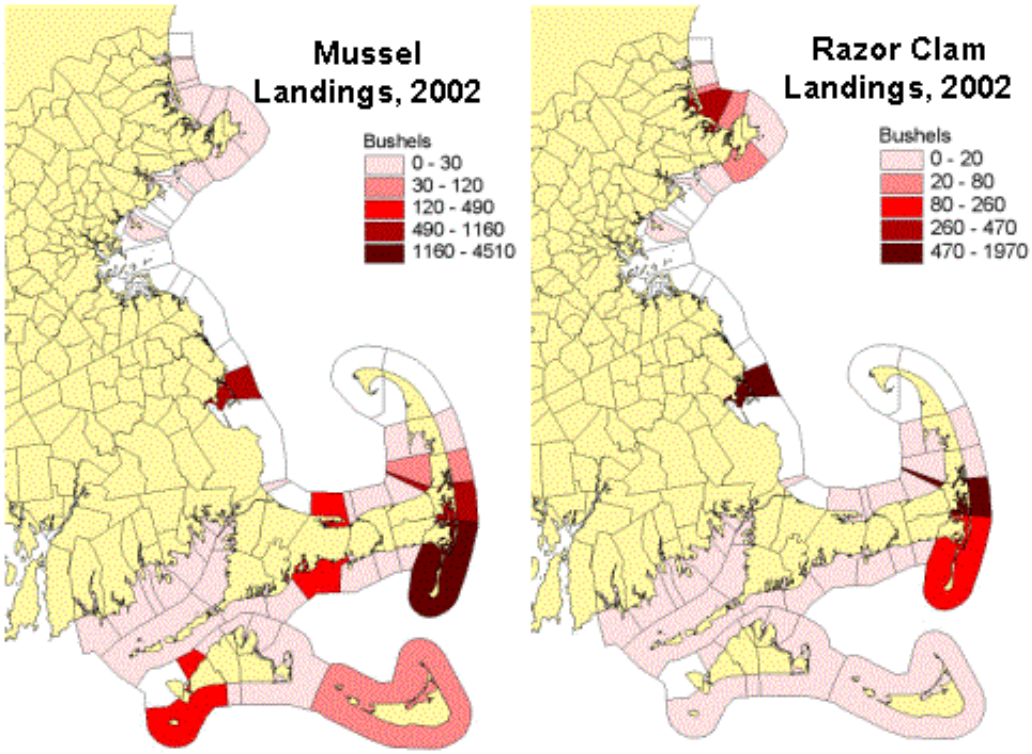


Figure 27. Mussel and razor clam landings for Massachusetts in 2002.

Surf Clam and Quahog Dredge Fisheries - Unlike other shellfisheries in non-contaminated waters that are under municipal control, the commercial harvest of surf clams and ocean quahogs are under *MarineFisheries* control. Likewise, *MarineFisheries* manages the harvest of northern quahogs using dredges in certain waters of the Commonwealth through a limited access licensing process. Currently, there are more than 125 active permit holders that are required to submit monthly catch reports. This catch information is maintained in a multifunctional database that enables fishery managers to determine CPUE, measure the impact of fishing in specific locations, conduct trend analysis, and determine the amount and value of landings. These data, including seasonal catch data (type of fishery and size composition) and landings information, are shared annually with NOAA Fisheries and are incorporated into the total U.S. landings data.

PUBLIC HEALTH

Public health protection is achieved as a result of sanitary surveys of shellfish growing areas to determine their suitability as shellfish sources for human consumption. The principal components of a sanitary survey include: 1) an evaluation of pollution sources that may affect an area, 2) evaluation of hydrographic and meteorological characteristics that may affect distribution of pollutants, and 3) an assessment of water quality.

Each growing area must have a complete sanitary survey every twelve years, a triennial evaluation, and annual review in order to maintain a classification that allows shellfish harvesting. Minimum requirements for sanitary surveys, triennial evaluations, annual reviews, and annual water quality monitoring are established by the ISSC and set forth in the NSSP. Each year water samples are collected at 2,320 stations in 294 growing areas in Massachusetts coastal waters at a minimum frequency of five times while open to harvesting. Water and shellfish samples are tested for fecal coliform bacteria at two *MarineFisheries* laboratories located in Gloucester and Pocasset using a Most Probable Number (MPN) method (American Public Health Association) for classification purposes and a membrane filtration technique (usually M-tec) for pollution source identification.

Shellfish are also tested for various poisonous or deleterious substances based upon an assessment of pollution sources impacting growing areas as determined by the sanitary survey and also as a result of pollution events such as oil and chemical spills. Contaminants periodically recovered from shellfish include hydrocarbons, heavy metals, pesticides, and polychlorinated biphenyls (PCBs). Action and Tolerance levels have been established by the U.S. Food & Drug Administration (FDA) for various contaminants to protect the public.

Biotoxin Monitoring

Besides protecting the public from shellfish borne fecal pathogens, another major aspect of the shellfish program involves monitoring for naturally occurring marine biotoxins produced by the microscopic algae *Alexandrium* spp., also known as "Red Tide", that cause paralytic shellfish poisoning (PSP). Consumption of shellfish containing certain levels of PSP toxin can produce severe illness and even death. Shellfish Program personnel collect shellfish from 15 primary or sentinel stations weekly from April through mid-November. Samples are sent to the *MarineFisheries* laboratory in Gloucester where bioassays determine the levels of toxin in the shellfish. If toxin is found, both the frequency of sampling and the number of sample sites are increased. Shellfish areas are closed if toxin levels exceed safe limits. In addition to bioassays, the

Shellfish Program oversees a pilot phytoplankton monitoring program under a grant from the U.S. FDA, Office of Seafood. "Volunteers" (mostly local shellfish department personnel or others with strong biology backgrounds) trained and equipped with field microscopes and plankton nets by *MarineFisheries* and FDA, collect and analyzed hundreds of phytoplankton samples. The purpose of this program is to augment the shellfish analysis by providing early warning of potentially toxic blooms besides *Alexandrium* such as *Dinophysis* and *Psuedonitzchia* and to expand the number of sites being monitored along the coast.

Other Activities

Another component of the sanitation program involves maintaining a direct link with the state Department of Public Health (DPH) on all matters related to shellfish safety and public health protection. *MarineFisheries* provides information regarding harvest area status and assists DPH in tracing the source of shellfish in commerce. The agency also aids DPH in the regulation of shellfish wet storage by wholesale dealers and Shellfish Program personnel certified by FDA as Laboratory Evaluation officers evaluate non-state laboratories that conduct shellfish related analyses.

CONTAMINATED SHELLFISH RESOURCES

Under the relay program, *MarineFisheries* permits municipalities to relocate contaminated shellfish to clean waters for natural purification and propagation. Relays are conducted under stringent NSSP guidelines and are heavily supervised by state and local enforcement authorities. Contaminated shellfish must remain at the relay site for a minimum of three months and also for the duration of one spawning season. Shellfish are tested prior to relaying and again before harvesting for human consumption to insure that they meet NSSP requirements for safety. The northern quahog is most often transplanted at around 14-18,000 bushels a year. Oysters and soft-shelled clams are also moved. Most contaminated quahogs are obtained from the waters of the Taunton River - Mount Hope Bay area, and the waters of New Bedford, Fairhaven, and Dartmouth. This method of shellfish propagation affords participating municipalities a relatively inexpensive source of shellfish for use as spawning stock and also allows eventual utilization of the contaminated resource thus eliminating the temptation of illegal harvesting by removing the stock from contaminated areas.

Depuration

The management and oversight of soft-shell clam depuration is a substantial activity for *MarineFisheries*. Clams are harvested from specially designated, conditionally restricted areas of Boston Harbor and transported by *MarineFisheries* licensed and bonded master diggers under strict enforcement to the Shellfish Purification Plant located on Plum Island in Newburyport. Once at the Shellfish Purification Plant, the clams are treated in a controlled aquatic environment and purified. The Shellfish Purification Plant is a state of the art facility containing nine depuration units. Pure seawater is obtained from two deep salt-water wells and is continuously disinfected using ultra-violet light. Depuration is a complex biological process requiring constant validation, during and upon completion of the treatment, through testing of shellfish and tank water. This is accomplished by daily testing in an on-site certified laboratory. The depuration process occurs for a minimum of three days and upon completion, the clams are returned to the harvesters, who pay a depuration fee. The purified clams are then sold in commerce.

The Newburyport Shellfish Purification Plant, in operation since 1928, is the oldest and largest continually operating depuration facility in the country. It is also the only publicly owned and operated depuration plant in the United States. The plant is open 364 days a year and processes an average of 560 bushels of soft-shelled clams per week.

Contaminated Bait

Currently, the only contaminated shellfishery for bait is the heavily regulated, occasional surf clam dredge boat fishery. Recent activity has been minimal.

Environmental Protection

Shellfish Program personnel respond to pollution events in coastal waters in order to assess possible damage to shellfish resources and to determine the need for public health closures. These events include sewage discharges, boat sinkings, petrochemical spills, and other discharges of hazardous chemicals.

AQUACULTURE MANAGEMENT

A major management and technical assistance endeavor of the Shellfish Program is the regulation of shellfish aquaculture. This activity involves two areas of concern: licensing of sites by municipalities and the permitting of aquaculturists to obtain and possess sub-legal shellfish (seed) for transplant and grow-out to legal size. *MarineFisheries* aids municipalities by certifying after inspection of the project area, (as required by statute Chapter 130, Sec. 57; MGL) that the license and operation will cause no substantial adverse effect on shellfish or other natural resources of the city or town. Aquaculturists are required to obtain an annual *MarineFisheries* propagation permit specific to the needs of the individual grower based upon a permit application. The purpose of this process is to control the introduction of shellfish diseases, non-native shellfish species and other pests or predators into Massachusetts waters. About 300 propagation permits are issued each year. Other related activities include: assisting individuals in the licensing and permitting process, providing information on aquaculture to interested parties, assisting municipalities with site selection prior to formal site survey in order to avoid *MarineFisheries* denial, and assisting growers in finding seed sources, and working with hatcheries to become certified to sell seed in Massachusetts.

LITERATURE CITED AND SUGGESTED READINGS

See - http://www.state.ma.us/dfwele/dmf/Publications/technical.htm - for listing of *MarineFisheries* technical reports.

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74. Fishery Bulletin of the Fish and Wildlife Service. Volume 53. Washington DC. 577pp.

Chase, B. C., J. Plouff, and W. Castonguay. 2003. A study of the marine resources of Salem
Sound, 1997. Massachusetts Division of Marine Fisheries Technical Report TR-6.

Clark, S.H. (ed.). 1998. Status of fishery resources off the Northeastern United States for 1998. NOAA [National Oceanic and Atmospheric Administration] Tech. Memo. NMFS-NE-115. 149p.

Chesmore, A. P., D. J. Brown, R. D. Anderson. 1972. A study of the marine resources of Lynn-
Saugus Harbor. Massachusetts Department of Natural Resources Monograph Series 11.

Chesmore, A. P., D. J. Brown, R. D. Anderson. 1973. A study of the marine resources of Essex.
Massachusetts Department of Natural Resources Monograph Series

Chesmore, A. P., S. A. Testaverde, F. P. Richards. 1971. A study of the marine resources of
Dorchester Bay. Massachusetts Department of Natural Resources Monograph Series 10.

Curley, J. R., et al. 1971. A study of the marine resources of the Waquoit Bay- Eel Pond Estuary. Massachusetts Department of Natural Resources Monograph Series 9.

Curley, J. R., et al. 1972. A study of the marine resources of Wellfleet Harbor. Massachusetts
Department of Natural Resources Monograph Series 12.

Curley, J. R., et al. 1974. A study of the marine resources of the Taunton River and Mount Hope
Bay. Massachusetts Department of Natural Resources Monograph Series 15.

Curley, J. R., et al. 1975. A study of the marine resources of Bass River. Massachusetts Department of Natural Resources Monograph Series 16.

Currier, T.P., J.R. King, and R. Johnston. 2003. United States Fish and Wildlife Service Federal
Aid to Sport Fish Restoration Act Annual Report. Project No. F-56-R. Resource Assessment.
Massachusetts Division of Marine Fisheries. Pocasset, MA.

Estrella, B. T., and R. P. Glenn. 2003. Massachusetts coastal commercial lobster trap sampling
program May-November, 2001. Massachusetts Division of Marine Fisheries Technical

Report
TR-14.

Iwanowicz, H. R., R. D. Anderson, B. A. Ketschke. 1973. A study of the marine resources of
Hingham Bay. Massachusetts Department of Natural Resources Monograph Series 14.

Iwanowicz, H. R., R. D. Anderson, B. A. Ketschke. 1974. A study of the marine resources of
Plymouth, Kingston, and Duxbury Bay. Massachusetts Department of Natural Resources Monograph Series 17.

Jerome, W. C., A. P. Chesmore, C. O. Anderson. 1966. A study of the marine resources of
Quincy Bay. Massachusetts Department of Natural Resources Monograph Series 2.

Jerome, W. C., A. P. Chesmore, C. O. Anderson. 1967. A study of the marine resources of
Beverly-Salem Harbor. Massachusetts Department of Natural Resources Monograph Series 4.

Jerome, W. C., A. P. Chesmore, C. O. Anderson. 1968. A study of the marine resources of the
Parker River-Plum Island Sound Estuary. Massachusetts Department of Natural Resources
Monograph Series 6.

Jerome, W. C., A. P. Chesmore, C. O. Anderson. 1969. A study of the marine resources of the
Annisquam River-Gloucester Harbor Coastal System. Massachusetts Department of Natural
Resources Monograph Series 8.

Jerome, W. C., et al. 1965. A study of the marine resources of the Merrimack River Estuary.
Massachusetts Department of Natural Resources Monograph Series 1.

Lawton, R.P., R.D. Anderson, P. Brady, C. Sheehan, W. Sides, E. Kouloheras, M. Borgatti, and
V. Malkoski. 1984. Fishes of western inshore Cape Cod Bay: studies in the vicinity of the
Rocky Point shoreline, p. 191-230. In: J. D. Davis and D. Merriman (editors), Observations on
the Ecology and Biology of Western Cape Cod Bay, Massachusetts. Springer-Verlag, Berlin,
F.R.G. 289 pp.

Nelson, G.A., and T. B. Hoopes. 2003. Massachusetts 2002 Striped Bass Monitoring Report.
Massachusetts Division of Marine Fisheries Technical Report TR-19.

2. MARINE MAMMALS AND TURTLES

The coastal and offshore marine waters of Massachusetts provide habitat for many species of whales, porpoises, dolphins, seals (Table 1) and turtles (Table 2). From the times prior to the colonization of Massachusetts to the present, marine mammals and turtles have always had an important role in the lives of the coastal residents.

Within coastal and offshore waters of Massachusetts, 34 species of marine mammals and turtles are documented (Table 1 and 2). These species include 17 whales, five dolphins, one porpoise, four seals, the walrus, five marine turtles and one coastal turtle (Cardoza and Mirick 1987; Cardoza 1979).

Table 1. List of marine mammals found in Massachusetts waters and population estimates.

COMMON NAME	SCIENTIFIC NAME	OCCURRENCE IN MASSACHUSETTS & POPULATION ESTIMATE
Northern Right Whale	*Eubalaena glacialis*	A U.S. and state-listed endangered species. Formerly stranded frequently. Recently observed in waters of Plymouth, Barnstable, and Nantucket counties. Most of Cape Cod Bay included in designated federal Critical Habitat. Minimum population estimate is 201*.
Minke Whale	*Balaenoptera acutorostrata*	Inshore waters; stranded Barnstable and Essex Counties. Minimum population estimate 3,515*.
Sei Whale	*Balaenoptera borealis*	A U.S. and state-listed endangered species. Stranded in Plymouth and Barnstable counties. No minimum population estimate is available*.
Blue Whale	*Balaenoptera musculus*	A U.S. and state-listed endangered species. Stranded in Essex County. Minimum population estimate 308*.
Fin Whale	*Balaenoptera physalus*	A U.S. and state-listed endangered species. Formerly common offshore. Stranded in Plymouth, Barnstable, and Dukes Counties. Minimum population estimate 2,362*.
Humpback Whale	*Megaptera novaeangliae*	A U.S. and state-listed endangered species. Observed in Plymouth and Essex county waters, stranded Barnstable and Nantucket Counties. Minimum population estimate 647*.
Common or Saddle-backed Dolphin	*Delphinus delphis*	Reported from Barnstable and Dukes Counties. Minimum population estimate 23,655*.
Long-finned Pilot Whale	*Globicephala melaena*	Occurs in schools, frequently stranded. Reported from Essex, Barnstable, Dukes, and Nantucket Counties. Minimum population estimate 11,343*.
Grampus or Risso's Dolphin	*Grampus griseus*	Offshore; observed Dukes County waters. Minimum population estimate 22,916*.
Atlantic White-sided Dolphin	*Lagenorhynchus acutus*	Coastal waters; stranded in Barnstable and Dukes Counties. Minimum population estimate 37,904*.
White-beaked Dolphin	*Lagenorhynchus albirostris*	Coastal waters; reported from Essex and Barnstable Counties. Minimum population estimate is not available*.
Orca or Killer Whale	*Orcinus orcus*	Offshore waters; stranded in Barnstable County. Minimum population estimate is not available*.

Table 1. List of marine mammals found in Massachusetts waters and population estimates (cont'd)

Harbor Porpoise	*Phocoena phocoena*	Coastal waters; reported from Essex, Bristol, and Dukes Counties. Minimum population estimate 74,695*.
Striped Dolphin	*Stenella coeruleoalba*	Pelagic; reported from Essex, Plymouth, and Barnstable Counties. Minimum population estimate 44,500*.
North Atlantic Bottle-nosed Dolphin	*Tursiops truncatus*	Inshore waters; stranded in Plymouth County. Minimum population estimate 24,897 for the offshore population not available for the coastal population*.
Pygmy Sperm Whale	*Kogia breviceps*	Offshore waters; stranded in Essex county and recorded in Bristol County waters. Minimum population estimate 617*.
Beluga	*Delphinapterus leucas*	Observed in waters of Essex and Barnstable Counties. Minimum population estimate not available*.
Sperm Whale	*Physeter catodon*	A U.S. and state-listed endangered species. Formerly abundant offshore; stranding in Barnstable, Dukes, Essex, and Nantucket Counties. Minimum population estimate 3,505*.
Bottle-nosed Whale	*Hyperoodon ampullatus*	Pelagic, stranding in Barnstable County. Minimum population estimate is not available*.
North Atlantic Beaked Whale	*Mesoplodon bidens*	One record, Nantucket County. Minimum population estimate 2,419*.
Tropical beaked Whale	*Mesoplodon densirostris*	One record, Essex County. Minimum population estimate 2,419*.
True's beaked Whale	*Mesoplodon mirus*	Offshore waters; no recorded stranding.
Goose-beaked Whale	*Ziphius cavirostris*	Pelagic, stranding in Barnstable and Dukes Counties.
Walrus	*Odobenus r. rosmarus*	Accidental straggler. Recorded Plymouth County, 1734.
Hooded Seal	*Cystophora cristata*	Accidental straggler. Recorded Essex County. Minimum population estimate is not available*.
Gray Seal	*Halichoerus grypus*	A state-listed species of Special Concern occurring in Nantucket, and occasionally Dukes, County waters. Also recorded on coast of Essex county, probably as a vagrant from Maine water Minimum population estimate is not available*.
Harp Seal	*Phoca groenlandica*	Accidental straggler. Recorded Essex County. Minimum population estimate is not available*.
Harbor Seal	*Phoca vitulina concolor*	Coastal Massachusetts. Minimum population estimate is 91,546*.

Table 2. Sea turtles found in Massachusetts.

COMMON NAME	*SCIENTIFIC NAME*	OCCURRENCE IN MASSACHUSETTS & POPULATION STATUS
Loggerhead Turtle	*Caretta caretta*	A U.S. and state-listed endangered species. Recorded from coastal southeastern Massachusetts.
Green Turtle	*Chelonia mydas*	A U.S. and state-listed endangered species. Recorded from coastal Barnstable County.
Hawksbill Turtle	*Eretmochelys imbricata*	A U.S. and state-listed endangered species. One confirmed record (NOAA records and Bob Prescott, New England Aquarium).
Atlantic (Kemp's ridley) Turtle	*Lepidochelys kempi*	A U.S. and state-listed endangered species. Recorded from coastal Barnstable County.
Leatherback Turtle	*Dermochelys coriacea*	A U.S. and state-listed endangered species. Recorded from coastal southeastern Massachusetts. Older records from coastal Essex and Suffolk Counties.
Diamondback terrapin	*Malaclemmys terrapin*	A U.S. and state-listed endangered species. Coastal areas of Barnstable, Bristol, and Plymouth counties. Introductions of terrapins from extraliminal sources occurred on at least two occasions.

* Minimum Population estimates from Waring et. al. 2002

All six species of turtle and all six of the large whales species are currently listed on the Federal or States list of threatened and endangered species.

MONITORING

Payne et. al (1990) described current and past monitoring and research of marine mammal and turtle populations in the waters of and adjacent to Massachusetts. All research and monitoring was used as sources for the status, trends, and estimated population size (Tables 1 and 2). Many organizations, such as Manomet Bird Observatory, the Center for Coastal Studies (Provincetown), New England Aquarium (Boston), and Whale Center of New England (Gloucester), monitor and research marine mammals and turtles in Massachusetts and the northwest Atlantic Ocean. Additionally, the use of newspaper clippings (i.e., anecdotal statements) was used to verify sightings or strandings (if this information was not available from a more rigorous literature source).

The University of Rhode Island, New England Aquarium, Center for Coastal Studies, and the Woods Hole Oceanographic Institution, in a Cooperative Agreement with the National Marine Fisheries Service established an "Integrated Program for Research on the Northern Right Whale off the Eastern United States." The program consists of four principal tasks: database management, aerial surveys, shipboard surveys, and photoidentification.

The Marine Mammals Investigation of the NOAA Fisheries does aerial and shipboard line transect surveys in the region from the Gulf of Maine to Florida. The Northeast Fisheries Science Center Sea Sampling Program has collected data on fishing activity and marine mammal interactions since June 1989. Trained observers are used on board randomly selected fishing vessels. The current level of observer coverage is approximately 10 percent of the fishing effort.

Monitoring is also provided by observers that are required as a permit condition, such as dredged material disposal, following a formal review under the provisions of Section 7 of the Endangered Species Act.

POLLUTANT CONTAMINATION

Marine mammals and reptiles occupy several trophic levels of the marine food web and are potential repositories for oceanic contaminants that pass through the food chain. Stranded inshore species provide information on regional trends in contaminant concentration. Offshore species signal the extent to which the seas are being despoiled. Inshore and offshore groups reveal the influence of contaminants and toxins on the health of marine environment. A commitment to collection and long-term storage of marine mammal tissues will enable scientists to monitor occurrence patterns of biological toxins, organochlorines, heavy metals and other contaminants, and this can guide future policy (Geraci and Lounsbury 1993).

In analyzing the data for our waters, the EPA wrote in its Section 7 determination for the Massachusetts Water Resources Authority's Boston Harbor sewage outfall project, "Only trace concentrations of several synthetic organochlorine chemicals were detected in blubber samples collected by biopsy darts from free-ranging right whales in the Bay of Fundy and on Browns/Baccaro Banks off Nova Scotia, Canada." These trace contaminations were polychlorinated biphenyls (PCBs), the pesticide DDT, and its metabolites.

This same EPA report shows that organic and metal pollutants were reported in the tissues of several species of cetaceans from a wide geographic range of habitats. As a general rule, highest concentrations of pollutants are found in toothed cetaceans that feed on large fish and other marine mammals, such as killer whales. Somewhat lower concentrations are found in other toothed cetaceans that feed on a variety of fish and invertebrate prey, particularly in nearshore waters, such as beluga whales (*Delphinapterus leucas*), long-finned pilot whales (*Globicephala melaena*), and harbor porpoises (*Phocoena phocoena*). Among the baleen whales (whales that feed on small shoaling fish and crustaceans, such as humpback whales (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalis*), higher concentrations of synthetic organochlorines are usually found in blubber and other tissues, compared to whale species that feed primarily or exclusively on herbivorous zooplankton, such as right whales.

Interspecies differences in body burdens of potentially toxic metal and organic contaminants are related to trophic position of the cetacean. Body burdens of many contaminants increase from lower to higher trophic levels in the marine food web. Thus, the right whale, because it feeds at a low trophic level, is less vulnerable to chemical pollution of the marine food web than other cetaceans, such as the humpback and fin whales that feed at a higher trophic level. Although residue levels of some pollutants are very high in some individuals, there is little direct evidence that the residues have impaired reproductive success or cetacean health (USEPA 1993).

SUMMARY

Due to the fact that the marine mammals and reptiles inhabiting Massachusetts coastal waters are geographically wide ranging and the factors that limit their survival are still considerably unknown to science, their protection and management can best be accomplished in cooperation with national and international agencies. The Commonwealth of Massachusetts contributes to the overall effort to protect these rare species and their habitats by sponsoring research, monitoring for their presence, and informing ocean user groups. The most frequent causes of human-induced mortalities to marine mammal and reptile species in our area are ship strikes and entanglements with fishing gear. Methods to reduce these mortalities through new and innovative technologies, and vessel and gear management must be actively pursued.

LITERATURE CITED AND SUGGESTED READINGS

Cardoza, J.E. and P.G. Mirick. 1987. List of the Reptiles and Amphibians of Massachusetts (2nd ed.) Massachusetts Division of Fisheries and Wildlife. Fauna of Massachusetts Series No. 3., 12pp.

Cardoza, J.E. 1979. List of the Mammals of Massachusetts (2nd ed.) Massachusetts Division of Fisheries and Wildlife. 8pp.

Geraci, J.R. and V.J. Lounsbury. 1993. Marine Mammals Ashore, A Field Guide for Stranding. Texas A&M University. Sea Grant Program. 305pp.

Payne, P.M., C. Coogan, F.Wenzel, M. Buehler and A.L. Hankin. 1990. Living Resources of Buzzards Bay - Status and Assessment of the marine Mammal and Marine Turtle Species of Buzzards Bay, Massachusetts: A Historical and present Overview. 58pp.

United States Environmental Protection Agency. 1993. Assessment of Potential Impact of the MWRA Outfall on Endangered Species, Biological Assessment prepared pursuant to Section 7 of the Endangered Species Act. 3-13.

Waring, G. T., J. M. Quintal and C. Fairfield. 2002. U. S. Atlantic and Gulf of Mexico Marine Mammal Stock Aassessments - 2002. NOAA Tech. Memo. NMFS-NE-169, 328 pp. http://www.nmfs.noaa.gov/prot_res/readingrm/MMSARS/2002AtlanticSARs.pdf

3) SEABIRDS, SHOREBIRDS, WATERFOWL AND COLONIAL WATERBIRDS

Birds that are associated with the coast and ocean are divided into four categories: seabirds, shorebirds, waterfowl, and colonial waterbirds.

Seabirds spend most of their lives on the open waters of the ocean, coming to land only to breed. These types of birds are further divided into two groups, coastal or nearshore and oceanic or pelagic. The coastal group is usually found within three miles of land and includes the sea ducks, loons, grebes and gulls. The oceanic group is further off shore and includes shearwaters, petrels, puffins, fulmars, gannets, phalaropes, skuas, kittiwakes, jaegers, and auks.

Shorebirds are migratory and use estuaries and freshwater habitats for breeding, summering, and wintering. They migrate northward in the spring and southward in the fall. Approximately 30 species such as plovers, sandpipers, avocets, and oystercatchers are shorebirds. Shorebirds swarm wetlands, beaches, marshes, and tidal flats looking for food and shelter as they migrate through the region.

Waterfowl spend most of their time in the water and have webbed feet designed for swimming. In Massachusetts there are native species of waterfowl that regularly use the estuaries, rivers, and wetlands for breeding and migratory species that use the coastal areas as a winter habitat or to stop and rest as they migrate. Examples of species that nest and breed in Massachusetts include the mallard, American black duck, and the Canada goose. The brant, greater scaup, and bufflehead are examples of birds that winter here and migrate north for the summer.

Colonial waterbirds and wading birds that nest in colonies along the coast in concentrated areas. There are about 23 species of colonial waterbirds in the Massachusetts coastal area. Examples are cormorants, herons, egrets, ibises, gulls, terns, and skimmers.

POPULATION STATUS OF BIRDS

In Massachusetts among the birds associated with the coast, the Common Loon, Common Tern, Artic Tern, and Least Tern are species of Special Concern under the Natural Heritage Program. The Piping Plover is a Threatened Species and the Pied-Billed Grebe, Leach's Strom-Petrel, American Bittern, Least Bittern and the Roseat Tern are endangered species.

The U.S. Fish and Wildlife Service (USFWS) notes that populations of many species of the wading birds are greatly depressed compared to 100 years ago due to the loss of wetlands. Cormorants on the other hand are over abundant and threaten economic interests such as aquaculture. The cormorant is also a suspect in the decreasing abundance of local sportfish populations. A national management plan for the double crested cormorant was just released. Surveys of colonial waterbirds are conducted on a regular basis but are not standardized. Standardized monitoring techniques are needed, as well as a better understanding of the relationship of the waterbirds to their environment.

The USFWS notes that because many breeding species of shorebirds are dispersed across wide, inaccessible areas, accurate estimation of population sizes is difficult. Some populations are small and warrant special attention, such as the piping plover in Massachusetts. It is believed that many populations of shorebirds are declining, based on counts made during migrations and on the breeding grounds.

Because many waterfowl species are hunted, they are monitored through surveys, harvests, and evaluations of their habitats. The USFWS "Waterfowl Population Status, 2003" notes that the total duck population estimate was 16% higher than the 2002 estimate. The mallard populations were similar but the blue-winged teal, shovelers, and pintail were above last years estimate while gadwall, American wigeon, green-winged teal, redheads, canvasbacks, and scaup were unchanged from their 2002 estimates. In the eastern survey area, total duck population was 17% lower than last year but similar to the 1996-2002 average with the exception of mergansers that decreased 30% from the 2002 estimate. For the northeastern U.S. (New England plus the mid-Atlantic states), overall populations were down 11%. For Canada geese, the Atlantic flyway resident population has increased about 12% since last year's count. The estimates for this population have increased 4% per year since 1994. The greater snow goose population increased 2% per year since 1994; the number counted in the Atlantic Flyway was 7% higher than the previous survey. The 2003 estimate of Atlantic brant in the Atlantic Flyway was 9% fewer than last year's estimate but the estimates overall for the last ten year period have increased 3% per year.

LITERATURE CITED AND SUGGESTED READINGS

Blodget, B. 1998. Checklist of the Birds of Massachusetts, Massachusetts Division of Fisheries and Wildlife.

Massachusetts List of Endangered, Threatened and Special Concern Species, Massachusetts Division of Fisheries and Wildlife, Natural Heritage Program http://www.state.ma.us/dfwele/dfw/nhesp/nhrare.htm

U.S. Fish and Wildlife Service. 2003. Waterfowl population status, 2003. U. S. Department of the Interior, Washington, D.C. 53 pp.

U.S. Fish and Wildlife Service. 2002. Shorebirds, Waders of Shores, Wetlands and Grasslands.

U.S. Fish and Wildlife Service. 2002. Colonial-Nesting Waterbirds, A Glorious and Gregarious Group.

U.S. Fish and Wildlife Service, Shorebirds, http://www.fws.gov/r5snep/shrbrd-grp.htm

U.S. Fish and Wildlife Service, Waterfowl, http://www.fws.gov/r5snep/wtrfwl-grp.htm

U.S. Fish and Wildlife Service, Seabirds, http://www.fws.gov/r5snep/seabrd-grp.htm

U.S. Fish and Wildlife Service, Colonial Waterbirds, http://www.fws.gov/r5snep/wtrbrd-grp.htm

4) BENTHIC COMMUNITY

The purpose of this section is to summarize the trends observed in benthic community resources based on large-scale (temporal and/or spatial) surveys in Massachusetts coastal waters. The findings reported herein are not comprehensive but are intended to provide an indication of the level of information available for benthic resources.

Benthic community structure reflects the cumulative influences of numerous factors, both natural and anthropogenic, and both acute and chronic. In areas undisturbed by pollutants, physical conditions (including water depth, circulation, exposure, salinity, latitude, and, in particular, substrate) are the primary influences to community structure. The primary characteristics of benthic macroinvertebrate communities are fairly predictable when several of these physical factors are known. Healthy, balanced benthic communities are generally composed of high species richness with a number of species reaching similar abundance levels. The benthic community responds to water quality degradation (e.g., introduction of pollutants, hypoxia/anoxia), sediment quality (deposition of particles of differing grain size, introduction of sediment-bound contaminants), or physical disturbance (e.g., dredging, trawling, storms) by a reduction in species richness and replacement of a diverse community with one dominated by one or a few opportunistic species. The duration or frequency of the perturbation determines whether the benthic community is able to recover to its undisturbed condition. The benthic community can be used, therefore, as a snapshot characterizing the cumulative stresses occurring within a specific system.

Benthic resources range from microscopic sedentary infauna (e.g., polychaetes and small bivalves) and epifauna (e.g., hydroids) to mobile megafauna (e.g., lobsters and crabs) that provide significant functional value to the seafloor. The benthos is the basis for the food web for demersally-feeding fish and invertebrates. A number of benthic species (e.g. mussels) restructure the substrate and create habitat that is useful refuge for other species. Maintenance of a diverse benthic community in the coastal waters of Massachusetts is critical to maintaining the health of demersal fish populations.

Coastal waters of Massachusetts comprise a wide range of substrate conditions, resulting in high benthic habitat diversity. Substrate mapping is available for some areas, but not most. Increased coverage of substrate mapping will enable resource agencies to better comprehend the type and distribution of key resources, including benthic communities, so that they can be better managed.

Long-term benthic datasets for coastal waters of Massachusetts are limited in their spatial scale. MWRA has conducted surveys in Boston Harbor and Massachusetts Bay consistently since 1992. The EPA and Army Corps of Engineers have conducted periodic surveys in New Bedford Harbor in support of the Superfund cleanup efforts since 1993. More recently, additional long-term monitoring efforts have been initiated in Massachusetts Bay and Boston Harbor to document recovery of benthic resources following construction of the HubLine gas pipeline. Other portions of the coastal waters are less well documented, although the recent efforts undertaken, through the Massachusetts Ecosystem Assessment Program (MEAP; as part of EPA's National Coastal Assessment program) have expanded the geographic coverage. MEAP, a five-year program initiated in 2000, has sampled approximately 90 locations in Massachusetts coastal waters, with emphasis on estuarine locations and large, previously understudied coastal areas such as Cape Cod Bay, Nantucket Sound, and Buzzards Bay. This program includes sediment chemistry and fish surveys along with the benthic community analysis.

While this program is spatially comprehensive, few locations will be sampled repetitively. As a result, data can be used to identify areas of concern for future studies but can not readily identify trends. Results of benthic community studies are not currently available.

There are many examples of temporally and spatially limited benthic community studies. These studies may not provide evidence of trends in resource abundance and quality, but provide a 'snap-shot' of the condition of benthic resources and can serve as a baseline for subsequent monitoring. For example, the Massachusetts Office of Coastal Zone Management (CZM) assessed the benthos (using sediment profile imagery and benthic grabs) in Gloucester Harbor, Salem Sound, Boston Harbor, New Bedford Harbor, and Fall River Harbor. The CZM data are temporally limited, but contain a decent spatial coverage to characterize benthic resources in these harbors (CZM 2003). The benthic community around Gloucester's historic and new wastewater outfall has been monitored for years, providing a long-term but spatially limited data set to examine the benthos (e.g., Michael and Fleming 2000).

Boston Harbor and Massachusetts Bay

Benthic community is better known for Boston Harbor and Massachusetts Bay than many other parts of the coast because of the major construction projects that have occurred in these waters. Massachusetts Water Resources Authority (MWRA) has performed extensive benthic studies since 1989 in support of the upgrade of their sewage treatment facilities. Elimination of sewage sludge and sewage effluent discharges into Boston Harbor has resulted in dramatic improvements in water quality and benthic community structure. What was once a depauperate benthos comprising primarily small short-lived opportunistic species indicative of a highly enriched environment is now a relatively stable, diverse community with large populations of the amphipod *Ampelisca*, a favored food resource for winter flounder (Kropp, et al. 2002b).

Surveys documenting baseline conditions prior to the operation of MWRA's ocean discharge in 2000 have been conducted since 1992 (Kropp, et al. 2002a). The majority of the stations studied in this program have fine-grained substrates and the characteristic fauna dominated by polychaete worms. In sandy areas, polychaetes and amphipods dominate. These annual surveys have documented the natural variability that occurs in the soft-bottom benthic community. A significant storm in 1992, generating >7m waves, caused a substantial change in the soft-bottom community, including marked reductions in abundance and species richness. Both of these indicators gradually increased through 1999 and then started declining again. No noticeable effects were found after one year of discharge and no values were outside the caution threshold range established in MWRA's National Pollution Discharge Elimination System permit.

Surveys were conducted during two seasons (winter and summer) in various substrates along the HubLine corridor prior to construction to establish baseline conditions. Postconstruction monitoring is planned to take place for several years to confirm reestablishment of the benthic community in each substrate type.

In soft substrates that occurred along the majority of the route, the benthic community was dominated by polychaetes, although most areas were also inhabited by amphipods (TRC and NAI 2003a). The strongest station affinities were related to depth rather than sediment. Only one location in Boston Harbor was characterized by a high population of

an opportunistic species. In general, species richness was high, an indication of a healthy community.

The pipeline route crossed a limited amount of hard substrate in several areas. There were distinct spatial differences in community structure (TRC and NAI 2003b). Stations in Salem Sound were characterized by extensive growth of coralline algae and limited amounts of foliose algae and the reverse was true at stations near the mouth of Boston Harbor. Typical fouling species such as hydroids, bryozoans, tunicates, and sponges were common near Boston Harbor and rare in Salem Sound. Echinoderms (sea urchins and sea stars) were more numerous in Salem Sound. As the pipeline route was selected to purposely avoid hard substrate, the findings of this survey may not be representative of this habitat within Massachusetts Bay.

Glacial till substrate is difficult to sample and is generally avoided. Because the Massachusetts Bay seafloor is a mosaic of substrate conditions and glacial till has the potential to support early benthic phase lobsters, it was included in the HubLine monitoring program. Most glacial till stations supported a moderate abundance of benthic organisms (TRC and NAI 2003c). Species richness (number of taxa) in glacial till is high, a reflection of the diverse substrate with a variety of niches. Species ranged from infauna to sessile and motile epifauna.

New Bedford Harbor

Much of New Bedford Harbor, particularly the upper harbor, has been compromised by PCB and metals contamination. EPA developed a long-term monitoring program to document changes in the benthic community as Superfund cleanup operations progress. Baseline sampling was conducted in 1993. The benthic community exhibited a distinct gradient from the upper harbor to the outer harbor that paralleled sediment quality (Nelson, et al. 1996). The upper harbor supported a benthic community that was typical of a stressed environment, with dominance by opportunistic species and low species diversity while the benthic community in the outer harbor had high species richness and more evenly distributed species abundance. Benthos in the lower harbor was intermediate between the upper and outer harbor areas. Additional sampling was conducted in 1996 and 1999. Nelson (U.S. EPA-Narragansett, pers. comm.) indicated that little change in the benthos is evident over this time period, a finding that is consistent with the fact that only a small area of the harbor has been remediated to date.

SUMMARY

The benthic community is not systematically monitored in Massachusetts waters, with the exception of targeted monitoring for American lobster and areas impacted by the MWRA outfall and New Bedford's Superfund cleanup. Subsequently, no long-term datasets exist to document coast-wide trends in the abundance and composition in Massachusetts. The few data that exist provide an indication of trends in the benthic community, yet these monitoring programs are also limited to the relatively recent past (10 years). To fully understand trends in the benthic community, more detailed data is required and a targeted monitoring program needs to be developed and implemented.

LITERATURE CITED AND SUGGESTED READINGS

Kropp, R.K., R.J. Diaz, B. Hecker, D. Dahlen, J.D. Boyle, S.L. Abramson, S. Emsbo-Mattingly. 2002a. 2001 Outfall Benthic Monitoring Report. Boston: Massachusetts Water Resources Authority. Report ENQUAD 2002-15.

Kropp, R.K., R.J. Diaz, D.T. Dahlen, J.D. Boyle, and C.D. Hunt. 2002b. 2001 Harbor Benthic Monitoring Report. Boston: Massachusetts Water Resources Authority. Report ENQUAD 2002-19. 74 p. plus appendices.

Massachusetts Office of Coastal Zone Management (CZM). 2004. CZM 2004 http://www.state.ma.us/czm/publicationsdredge.htm

Michael, A.D. and S. Fleming. 2000. Gloucester 301(b) monitoring program 1999 annual report. Submitted to Gloucester Department of Public Works, Gloucester, MA. 84pp.

Nelson, W.G., B.J. Bergen, S.J. Benyi, G. Morrison, R.A. Voyer, C.J. Stroebel, S. Rego, G. Thursby, and C.E. Pesch. 1996. New Bedford Harbor Long-Term Monitoring Assessment Report: Baseline Sampling. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, Narragansett, RI. EPA/600/R-96-097.

TRC and Normandeau Associates, Inc. (NAI). 2003a. HubLine Pipeline Project Soft Substrate Benthos Monitoring. Second Pre-construction Survey. Prepared for Duke Energy Gas Transmission.

TRC and Normandeau Associates, Inc. (NAI). 2003b. HubLine Pipeline Project Hard Substrate Benthos Monitoring. Second Pre-construction Survey. Prepared for Duke Energy Gas Transmission.

TRC and Normandeau Associates, Inc. (NAI). 2003c. HubLine Pipeline Project Benthic Community Structure Associated with Glacial Till Substrate along the HubLine Route. Second Pre-construction Survey. Prepared for Duke Energy Gas Transmission.

5) MARINE BIOINVASIONS IN MASSACHUSETTS: AN OVERVIEW OF STATUS AND TRENDS

Human mediated marine invasive species introductions have likely been occurring in the northeastern United States since the beginning of European exploration and settlement. Some of our earliest invaders likely arrived as fouling or boring organisms on wooden ships, or as hitchhikers in solid and wet ballast. These early introductions include species such as the European green crab (*Carcinus maenus*) and wood-boring shipworms (three nonindigenous species) that continue to result in significant ecological and economic impacts.

Though ballast water continues to receive the most attention as a transport vector for marine and freshwater invaders, many other trade related mechanisms are also important species importers. The aquarium trade, aquaculture and the seafood industry, recreational boating, and marine research, to name just a few, have all been shown to be potential means of introduction. With the rise of global commerce and faster, more efficient shipping fleets, many researchers surmise that the result will increase introduction rates. Ruiz (2000) estimates that of the 374 marine invasions that occurred in the U.S. since the late 1700s, 150 occurred since 1970.

The marine invasive species picture in Massachusetts and the Gulf of Maine is incomplete. Carlton (2003), lists 85 introduced species and 67 cryptogenic species (species of unknown origin) that became established from Nova Scotia to Long Island Sound. This list was compiled based on literature surveys, personal observations, and some of the monitoring efforts cited below. However information related to the spatial coverage and ecological impacts of most of these species is limited. Marine invasive species monitoring efforts traditionally focused on tracking the population expansion of a few high profile species, or on localized surveys of species presence or absence in association with academic institutions.

The first comprehensive survey of nonindigenous species in Massachusetts occurred in the summer of 2000 when a team of taxonomists led by the Massachusetts Bays National Estuaries Program and MIT Sea Grant conducted a rapid assessment survey of 20 sites along the Massachusetts Coast. The survey focused on the fouling community and documented the presence of 24 nonindigenous and 49 cryptogenic species. Three of these species were new records for Massachusetts (Pederson 2001). This survey was repeated for many of the Massachusetts sites in the summer of 2003. Results are forthcoming.

Managers dealing with the invasive species issue in the northeast recognize the importance of improving monitoring and data management related to marine bioinvaders. The Massachusetts Office of Coastal Zone Management and the Northeast Aquatic Nuisance Species Panel are working to develop a web-enabled database of marine invaders in the region (the Marine Invader Database). The database will compile records from the rapid assessment surveys, localized monitoring efforts, and single species monitoring efforts to generate a more complete picture of historic introductions, as well as range expansion and potential impacts of marine bioinvaders. This database is expected to be web published by the spring of 2004.

Marine bioinvasions continue to be an important and difficult issue for marine resource managers. Threats not only include the potential for the new introduction of a catastrophic invader, but also the continued range expansion of already established

species. The recent colonization of George's Bank by the tunicate *Didemnum vexillum* is a prime example.

SUMMARY

The distribution of marine invasive species is poorly understood. Data management and management of the transport of these species will be an essential component of any effort to document trends in marine bioinvasions in Massachusetts. More information on the location of introductions, rate of population growth and spread, and species distributions is essential for developing prevention, control, and mitigation strategies for marine invaders. While ballast water is the best known transport vector for marine invaders, many other vectors (e.g., seafood industry, pet trade, and aquaculture) also transport invasive species. Engaging these industries through education and outreach will be essential for effective management of marine invaders. More information on priority transport vectors and marine invaders can be found in the Massachusetts Aquatic Invasive Species Management Plan, available at http://www.state.ma.us/czm/invasivemanagementplan.htm.

LITERATURE CITED AND SUGGESTED READINGS

Carlton, J. T. 2003. A Checklist of the Marine and Estuarine Organisms from Nova Scotia to Long Island Sound. Second edition. Unpublished Report. Williams College-Mystic Seaport. 16pp.

Pederson, J. 2001. Massachusetts 2000 Rapid Assessment Survey. Unpublished Report. MIT Sea Grant. 14pp.

Ruiz, G. M. 2000. Toward Understanding Patterns of Marine Invasions in Space and Time. J. Pederson (ed.). *Marine Bioinvasions: Proceedings of the First National Conference*. MIT Sea Grant 00-2. pp.37-39.